The Journal of HEREDITY

A DUSKY DUCKLING

(SEE PAGE 470)

Identical Triplets — *Bricks Without Straw*

Light-Phase Mallard Ducks — *Origin of Afrikander Cattle*

Yellow-Spot Character in the Bean

VOLUME 24 DECEMBER, 1933 NUMBER 12

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CONTENTS

ORIGINAL ARTICLES

Descent and Origin of the Afrikander Cattle
By H. Epstein 449

Bricks Without Straw, A Review
By J. H. Kempton 463

Light-Phase Mallard Ducks
By R. George Jaap 467

A Study of Identical Triplets
By L. W. Sontag and V. L. Nelson 473

The Inheritance of a Yellow-Spot Character in the Bean
By M. C. Parker 481

REVIEWS AND NOTES

Theories of Development 480

Grant to Institute of Forest Genetics 480

Index of Volume 24 487

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TYPICAL AFRIKANDER CATTLE

Frontispiece

Bull, cow, and calf of the native south African breed of cattle known as the Afrikander. This breed is descended, with very little admixture of the blood of European breeds, from the cattle of the Hottentots. It is very probable that the breed traces its origin to the mountain cattle which existed in Central Asia several thousand years ago. The Afrikander has many points of similarity with the Zebus of India, which also originated in Central Asia. Zebus were known in Egypt at least three thousand years ago, as is proven by drawings dating from that time. (See Figure 5.)

Recently the Afrikander breed has been introduced into the United States. It is hoped that it may serve as the foundation for a new breed especially adapted to the gulf regions of the United States. For this reason the history of the breed has as especial interest at this time.

DESCENT AND ORIGIN OF THE AFRIKANDER CATTLE

H. EPSTEIN

Welverdiend, Transvaal, South Africa

THE opinion is generally held that the red Afrikander cattle descend in direct line from one of the indigenous breeds of Africa.

It is possible that in the sixteenth century the Portuguese brought cattle from Portugal to the Cape for bartering purposes. This cannot be proved; but even if such importations of Portuguese cattle to South Africa have actually taken place, these have played no part in the evolution of the Afrikander breed. This they have influenced as little as have the red Devons which Lord Charles H. Somerset, the governor of the Cape during the years 1814-1826, imported to South Africa.

In fact, the settlers refused to cross the Afrikander cattle with European breeds. Van Rijneveld[10] who tried to induce the colonists to "improve" their cattle by the use of purebred bulls from the Netherlands, reported in 1804 that his endeavors had been unsuccessful, as the Boers regarded such cross-breds as slow and lazy.

This shows clearly that the Afrikander cattle were then already a special breed greatly valued by the settlers as draught animals.

This assertion by no means excludes the possibility of European cattle, especially Frieslands, having been crossed during the eighteenth and nineteenth centuries with Afrikanders. Netherlands cattle were first imported into South Africa during the time of Van Plettenbergh, who governed the Cape from 1775 to 1785.

A. Holm[7] denies this possibility by pointing out that the black markings, which would have characterized the descendants of a cross of Afrikander and Friesland cattle, are very difficult to eliminate by breeding. According to him the rare occurrence of atavistic black spots in pure-bred Afrikander cattle is a sure sign that an admixture of Friesland blood to the Afrikander breed has not taken place.

Although the writer shares Holm's opinion that Friesland cattle had no influence upon the evolution and further development of the Afrikander breed, his argument, as far as the color is concerned, cannot be regarded as sound.

During the eighteenth century, the cattle of the Netherlands were for the greater part uniformly red, that is to say, of a similar color to the Afrikander. Since ancient times they belonged to the original red breed of cattle which was spread over the whole of Central Europe. The black and white markings only came to the fore later on under the influence of importations from Jutland.[3] In East Friesland, three per cent of the Friesland cattle even today are uniformly red.

Therefore, it is probable that the Friesland cattle imported to South Africa during the period of the creation of the Afrikander breed were mostly red or red and white. Cross-breds of these and Afrikanders could not, therefore, have shown any black markings.

The authors who have hitherto studied the problem of the origin of the Afrikander cattle have attached an importance to the red color of the breed, which to our view is quite unwarranted. The uniformly red color of the Afrikander cattle owes its standing mainly to fashion and the taste of the breeders. This is illus-

trated by the fact that up to the beginning of the twentieth century the colors found in Afrikander cattle were red, red with white underline, red with white topline, and yellow.[4].

Of much greater importance is the fact that the Afrikander cattle differ in every respect from the cattle of the Netherlands. If the latter had exercised any influence upon the Afrikander breed, slight signs at least of such an admixture would be noticeable. This, however, is not the case. These two breeds have as little in common as have, for instance, the Jerseys and the grey Hungarian steppe oxen.

When we express the opinion that the Afrikander breed has in no way been influenced by an admixture of Friesland blood, we do not mean to say that the crossing of these two breeds did not occur. Indeed, since the first importation of Dutch cattle to South Africa such cross breeding has played an important rôle in the animal husbandry of this country. But the descendants of such crosses were hardly ever mated with Afrikander bulls, but either with similar crossbreds or purebred Frieslands. They have to be regarded as the ancestors of a special breed, the "Cape Cattle" which have almost entirely superseded the Afrikander in the Cape Province.

The old "Cape Cow" showed all the peculiarities of a mixed breed, heterogeneity in production, form and color, the power of resistance of the Afrikander and many of the dairy qualities of the Friesland cattle and other dairy breeds.

There cannot be the least doubt that more blood of the Afrikander cattle flows in the veins of the Frieslands registered in the South African herdbook than Friesland blood in those of the red Afrikander breed.

The Ancestors of the Afrikander Cattle

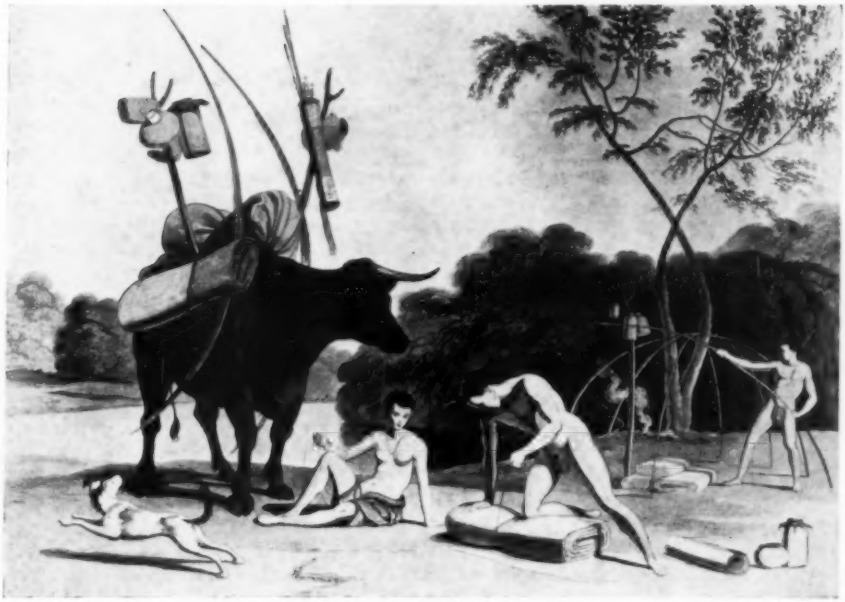
The red Afrikander is not a mixed, but a pure breed, evolved from indigenous African cattle by severe and careful selection. A mixed breed would never have been capable of such a marvellous preservation of its pure and uniform character in every part of this vast country as the red Afrikander cattle were after the profound economic changes following the Great Trek, the Rinderpest of the nineties and the destructive consequences of the Anglo-Boer War.

The cattle of the Hottentots formed the nucleus of the red Afrikander breed. The cattle of the Bantu peoples did not contribute to the creation of the Afrikander.

The color of the Bantu cattle is not uniform, though black predominates. The horns grow upwards and are long and thick, while those of the Hottentot cattle are much finer and in form and direction like those of the Afrikander. This peculiar direction of the horns led Stow[15] to conclude erroneously that the Namaqua had a practice of training the horns of their oxen artificially, confining their shape to a spiral line similar to that in the koodoo.

According to the picture of Hottentot cattle (Figure 1) they were extremely tall animals. The form of the head, horns and neck makes it clear that the Hottentot cattle and no other breed were the ancestors of the Afrikander. The thin, long tail with the well developed switch and the strong, clean legs are like those of the Afrikander cattle. Unfortunately, the load makes it difficult to judge the direction of the top line and the development of the hump, but the direction of the front pack indicates a considerable sloping down of the back behind the withers. In comparison with this big animal most breeds of Bantu cattle, of which a few pictures are to be found in the following part, are small and of poor appearance. This is confirmed by Mrs. A. Hoernle.[5]

The hump of the Hottentot cattle does not seem to have been very strongly



CATTLE OF THE HOTTENTOTS

Figure 1

"Korah Hottentots preparing to move," from *African Scenes* by Samuell Daniell, London, 1804-05. Resemblances in stature, shape of horns and other characteristics leave little doubt that the Hottentot cattle are direct progenitors of the Afrikander breed. (Reproduced by kind permission of W. P. Paff and of Mrs. A. Hoernle, Department of Bantu Studies, University of the Witwatersrand, Johannesburg.)

developed. But this fact is not surprising considering that the Hottentots lived, at the time of the European penetration into southern Africa, in one of the dryest and poorest parts of the subcontinent. The size of the hump of all Zebu cattle is easily influenced by feeding. For instance, it is frequently observed in zoological gardens that Zebus born there develop tremendous humps, whereas in their imported parents the hump is hardly noticable.

Dutch Settlement of the Cape

The history of the European settlement of the Cape shows no less than does the likeness between the Hottentot cattle and the Afrikander and the dissimilarity between the latter and the cattle of the Bantus, that no other breed but the cattle of the Hottentots can be regarded as the Afrikander's ancestors.

During the first decades after the occupation of the Cape by the Dutch East Indian Company the settlers at the Cape of Good Hope never met with Bantu tribes, but only with Hottentots.

During the centuries preceding the discovery of the Cape by Europeans, the nomadic pastoral Hottentots had wandered with their herds of cattle and flocks of sheep to the Cape. The first Europeans found the southern and southwestern parts of the Cape inhabited by Hottentots only. These were in possession of large herds of cattle and flocks of fat-tailed sheep. Van

Riebeek, the founder of the Dutch settlement at the Cape, describes the herds of the Hottentots in the surroundings of Table Bay as being as numerous as blades of grass in a field. Alsembic, the chief of the Namaqua Hottentots, alone is said to have possessed in 1661, 4,000 head of cattle and 3,000 sheep.[15]

In 1652, the East Indian Company acquired its first herd of cattle from the Hottentots. Van Riebeek organized frequent expeditions into the interior for the purpose of obtaining from the inhabitants cattle which were needed for provisioning the ships with fresh meat.

However, as the settlers took unfair advantage of the Hottentots, the latter eventually refused to barter with the Europeans. For weeks and months they used to pasture their herds in full view of the European settlement, but would not part with their animals. A serious situation arose in consequence. The Company had to furnish provisions for the ships clearing from the Cape on the long voyages to India and Europe. The crews of these ships totaled five to six thousand sailors a year and the provisioning of them resulted in a severe scarcity of fresh meat. Thus the Company was forced to devote itself to cattle breeding.

This undertaking was started in 1673 when war broke out between the Dutch and the Hottentots of the Cochoqua tribe, who in the previous year had sold the Cape Peninsula to the Company. Upon the Cochoquas being defeated their cattle were taken from them, and all attempts to regain these in the years following were unsuccessful.[11]

But not for long did the Company persevere in this pastoral enterprise; a quarter of a century later all agricultural undertakings were abandoned and the task of provisioning the stores of the Company with foodstuffs was left to the settlers.

These obtained their original herds of cattle by various means; by purchase from the Company, which again acquired its stock from the Hottentots, or by direct barter with the latter, a practice that could never wholly be stamped out even when private barter was forbidden, or, finally, by theft and pillage.[8] Only fifty years after Van Riebeek had obtained his first herd of cattle from the Hottentots by barter, the number of Hottentot cattle in the possession of European settlers amounted to 13,000.

In those days the Dutch desired nothing as much as the cattle of the Hottentots with which, however, the owners did not wish to part since they had few other needs and were fond of their herds. All expeditions into the interior were undertaken with the sole aim of obtaining cattle. Thus it is not difficult to understand that by the year 1797 the Cape Namaqua possessed only sheep. Their large herds of cattle had passed entirely into the hands of the settlers.[15]

Hottentot Cattle Extinct

Today purebred Hottentot cattle are no longer to be found, and the above picture of a Hottentot ox is probably the only one of its kind. But during the early decades of the nineteenth century many herds were still in existance. These, however, passed into the hands of the Europeans who were continually advancing.

Pure Hottentot cattle existed longest in South West Africa, where they were to be found up to the time of the rising of the Namaquas against the Germans. After their subjection the Namaquas were not allowed to keep cattle, but only a limited number of sheep and goats.[11]

The evolution of the red Afrikander breed commenced during the first decades of the Dutch settlement. Since, owing to the richer vegetation, the Hottentot cattle were stronger and better developed in the southern coast belt of the Cape than in the dry regions of the north and the west

coast, the Boers naturally preferred these when bartering or stealing.

As trek oxen they were unexcelled, and in view of the fact that the transportation of goods in the Cape Colony could only be performed by oxen, this quality became the determining factor in the breeding and further development of the Afrikander breed.

Molhuysen[9] is of opinion that not the cattle of the Hottentots, but imported animals are to be regarded as the ancestors of the Afrikander breed. He tries to prove this by pointing out that the Hottentots used their oxen solely for riding and carrying, and that the cows were poor milkers:

> It is probable that the colonists were dissatisfied with these cattle and soon looked around for other breeds. Various breeds were imported and of these one with exceptionally long horns was preferred. Towards the end of the eighteenth century a larger number of this particular breed appears to have been imported into South Africa. During the Great Trek their descendants drew the wagons of the Boers into the Highveld, where they formed the nucleus of the present Afrikander breed. C. Keller expresses the opinion that these cattle originated from the vicinity of Lake Tanganyika.

This theory of Molhuysen is entirely unfounded. No historical data point to such early importations of cattle by Europeans from the neighborhood of Lake Tanganyika. In fact, such importations would have been quite inconceivable at that time. And indeed, Molhuysen's reference to the fact that the cattle of the Hottentots gave little milk and were only used for carrying and draught purposes proves exactly that which it should deny, namely, the close relationship between the red Afrikander and the cattle of the Hottentots.

Color of Hottentot Cattle

The uniformity of the red color of the Afrikander breed is mainly due to fashion and selection. The cattle of the Hottentots showed various colors, though red animals predominated.

It was a common practice amongst the Hottentots to select their breeding animals according to color. As a rule every cattle owner kept and bred only animals of one and the same color and exchanged those that were different for animals of the desired color.[12] This probably served to facilitate the discrimination of the cattle of one owner from those of his neighbors. For the Hottentots did not hold their cattle in common, but in private ownership. It was, however, customary for those owners who dwelt as a community to graze their cattle together.

At the time when the European settlers obtained their cattle from the Hottentots, the dominance and hereditary purity of certain colors had been insured by previous selection.

It is the writer's opinion that the Afrikander cattle could easily have been bred black. That red has become the common color is mainly due to the taste of the first settlers of the East Indian Company, who evolved the breed from the Hottentot cattle.

Besides a small number of Huguenots these colonists were chiefly of Dutch and German origin.[16] We mentioned above that the cattle of the Netherlands were then uniformly red. In South, West, and Central Germany, whence most of the first German settlers had come, the peasants knew in those times no other cattle than the indigenous red breed. To the majority of the settlers at the Cape the red color of cattle was, therefore, most familiar.

It is probable that a peculiar tax introduced by the Dutch East Indian Company also contributed to the culling of black animals. The Boers were compelled to pay one stuiver* per head of cattle annually. But strangely, this tax was only imposed upon black animals. Those of other colors were exempted.

This tax on black cattle was originally in force in the districts of Stellenbosch,

*Stuiver = 1 penny.

Swellendam and Graaff Reinet only; but upon new districts being founded it was also extended to these.[8] Owing to this tax black cattle in the herd were undesirable.

Undoubtedly there were originally beside red animals some of other colors within the Afrikander breed. These, however, were gradually eliminated. Holm[6] expresses the opinion that this was chiefly due to the wish of the transport riders who, before the construction of the railways, conveyed goods by ox wagon for hundreds of miles. These vied with each other for the possession of the most beautiful and uniform spans. Red color, long, finely shaped horns, hard, flinty feet, sinewy legs, and quick movements were highly valued. It was the pride of the transport riders and many farmers of those days to possess a span of oxen composed of animals of uniform color and appearance. Thus it came about that animals of a certain type and color were selected for breeding purposes.

The Origin of the Cattle of the Hottentots

The opinion is generally held today that the Hottentots whose cattle, as we have shown, are established as the ancestors of the Afrikander breed, were originally a Bushman people.[11] The difference between the two races lies not so much anatomically as in language and especially in culture. This is due mainly to Hamitic influences, as in general the history of Africa south of the Sahara is nothing else but the history of thousands of years of penetration of Negro and Bushman races by peoples with Hamitic blood and Hamitic culture. Indeed, the Hamites were the great civilizing power of Africa, a power which, according to the period and the degree of its influence, impelled multitudinous creations.[13]

That the qualities by which the Hottentots differ from the Bushmen have to be ascribed to Hamitic influences is, on the one hand, proved by the fact that the grammatical peculiarities of the language of the Hottentots are characteristic of the group of Hamitic languages, on the other hand by the fact that the cattle and sheep of the Hottentots belong to breeds which have been brought to Africa by nomadic tribes belonging to the great Caucasian branch of the human race. The original inhabitants of Africa, the Negro and Bushman peoples, did not domesticate wild animals.

Various authors hold the opinion that the Hottentots spring from a mixture of Hamitic nomads, who had extended up to South West Africa in earlier times, with their forerunners, the Bushmen, whose original home has to be sought in the tropical parts of East and Central Africa. According to this theory, the birth of the Hottentot race must have taken place in South Africa. Against this, however, it is argued that the Hottentots came to South Africa in comparatively recent times; that their race characteristics vary but little; and, moreover, that signs of such a crossing are completely absent in historical times.

Moreover, the existance in the Tanganyika territory of the Sandave language, which has numerous roots, the click sounds and other grammatical peculiarities in common with the language of the Hottentots, and which, like the latter, probably originates from a mixture of the languages of the Hamites and Bushmen, indicates that the crossing of Hamites and Bushmen, which produced the Hottentot race, took place in East Africa. The fact that such habits and customs of the Hottentots as are connected with their pastoral life were completely developed at the time when their ancestors commenced their migration to the Southwest, also contradicts the theory of the origin of this race in South or South West Africa.

The assumption that the Hottentots originated from a mixture of the old Bushman population of East Africa

and early Hamitic and Semitic immigrants is probably the nearest approach to reality. From these they received their cattle and those peculiarities of their language by which they are distinguished from the Bushmen.

According to their own traditions, the Hottentots appear to have come from the lake district of Central Africa whence they were driven out at the end of the fourteenth century or the beginning of the fifteenth, by a more powerful race which was armed with bows and battle axes. At the beginning they travelled with their herds between the Tanganyika and Nyasa lakes in a southernly direction, turned to the west until, with their faces always towards the sunset, they reached the Atlantic Ocean a few degrees south of the Equator. With the ocean on their right they slowly wandered onwards, down the west coast of Africa. As the Hottentots only came into contact with the Bantus, who were then moving in a westernly direction along the south coast of Africa, at the beginning of the eighteenth century, it is obvious that when the Europeans first saw them at the Cape they had been there only a short while.[11]

Contacts With the Bantus

Since there are certain similarities in many words of the Hottentot and Bantu languages which deal with their domestic animals, a number of philologists hold the opinion that the Hottentots are indebted to the Bantus, and not to the Hamites for their cattle. This theory is supported by certain craniological similarities between the Hottentots and Bantus. Others oppose this belief, because individuals of pronounced Hamitic characteristics are also frequently met with amongst the Hottentots. The fact, that the Hottentots obtained their goats from the Bantus and not from the Hamites, is also brought forward in support of the theory that the Bantus are partly responsible for the origin of the Hottentots, and that the cattle and sheep of the latter are descendants of Bantu breeds.[2]

Schapera[11] does not deny the possibility that, besides Bushmen and Hamites, highly Hamiticised Bantu peoples may have had a share in the origin of the Hottentots. After all, even the Bantu races are indebted to a mixture of Hamitic immigrants with African Negroes for their origin.[13]

The author leans toward the opinion that the Hottentots obtained their cattle and sheep directly from Hamites or Semites, and this later than the Bantus did, as will be shown below. The goats they received at a much later period from the Bantus. But before they met them, they already had cattle and sheep and an old pastoral tradition.

The racial origin of the Hamites has not yet been definitely ascertained. The most widely held theory is that they originated from a mixture of the Negroid aborigines of northeast Africa with one of the races of the Caucasian family, that great branch of mankind to which almost all European nations belong.

Stegmann von Pritzwald[14] considers them a mixed people of the ancient aboriginal population of northeast Africa and Semitic nomadic immigrants from Asia.

The first domestic animals of the Hamites were sheep. As true wild sheep were not indigenous to Africa, it can be considered as certain that the Hamites brought their sheep with them from their homes in Asia. This is all the more likely, because the regions through which they had to travel on their long journey to Egypt were so inhospitable that large numbers of people would hardly have been able to traverse them without being in possession of the hardy, steppe-bred sheep.

The sheep of the ancient Egyptians, the oldest Hamitic people on African soil, were long-legged animals with long, thin tails. As far as we know today they are descended from *Ovis vignei cycloceros* Hutt.

SKULL OF PREHISTORIC CENTRAL ASIAN OX

Figure 2

Bos namadicus inhabited the mountain regions of Central Asia in prehistoric times. Bones of these cattle are found with early human remains but it is doubtful whether the species was domesticated. This species is considered to be the progenitor of the Zebu cattle of India. After Stegmann.

Thus, the first domestic sheep on the African continent, which probably reached Egypt through the Isthmus of Suez,[11] Africa's most northernly gateway, is of no importance for our purpose, as its origin is different from that of the fat-tailed sheep of the Hottentots.

Whether the Hamites were in possession of cattle at the time that they immigrated into Africa is uncertain. The old Egyptian Longhorn cattle appear to have been evolved in Egypt from the indigenous variety of the Urus, i. e. *Bos primigenius hahni nova* subspecies *Hilzheimer*. These longhorned cattle had a much greater influence on the African cattle than, for instance, the old Egyptian sheep had on the present African sheep. They still form the foundation stock of most breeds belonging to the Bantu peoples.

However, when Antonius[2] regards the cattle of the Watussi and Bechuana as typical descendants of the African Urus, *Bos primigenius Hahni,* his opinion is no less erroneous than that of Stegmann von Pritzwald,[14] who considers them longhorned Zebus.

Subsequently we shall describe the characteristics of the East and South African breeds of cattle more fully as this is necessary if we are to understand thoroughly the difference between the cattle of the Hottentots and the Bantu breeds.

The Bantu Breeds

While the indigenous Longhorn cattle of Egypt have to be regarded as the first domestic cattle of Africa, a breed of different origin entered Africa from Syria, Palestine and Arabia in early times, namely the Zebu (*Bos taurus indicus sive africanus*).

The Zebu, in its original form, is distinguished from other breeds by its

SKULL TYPE OF RED AFRIKANDER BREED

Figure 3

The shape of skull and horns of the Afrikander breed shows remarkable resemblance to the skull type of the prehistoric Central Asia cattle (Figure 2). Considering the great distance and the tremendous lapse of time that separates the two forms the resemblance is striking. After Molhuysen.

hump, which consists of fat and muscle tissues. The hump represents an accumulation of reserve material similar to the fat tail of various sheep and the humps of the camel and dromedary. Such local fat accumulations are caused by the conditions of the steppe, which is notorious for its acute changes from periods of drought to those with an abundance of grazing. In animals living in steppes these accumulations appear on those parts of their bodies where they will not impede their free movements. The hump of the Zebu cattle points, therefore, to a steppe country as the place of their evolution.

Stegmann is of the opinion that the northern or northeastern parts of India could not have evolved the Zebu, as the climatic conditions of India were unsuitable for creating a type of cattle so admirably adapted to the life of the steppe. The domestication of the Zebu probably took place in Central Asia, the cradle of human culture, where a humid, maritime climate prevailed as long as the present Mongolian desert was covered by the sea. The Zebu is descended from the Central Asiatic mountain cattle, *Bos namadicus Falk.*, which once lived wild in the mountain regions of Central Asia, and whose remains have been found together with those of an ancient human race. Antonius regards these Asiastic mountain cattle as a local subspecies of the great group of *Bos primigenius*, which in

earlier times was widely spread over Asia, North Africa and Europe.[2]

The Zebu cattle are supposed to have acquired their steppe characteristics after the Mongolian Sea had broken through its mountain barriers and its waters had drained away, an event which had the most far-reaching effects upon the history of mankind. Owing to the drying up of the sea and the formation of the great Mongolian desert the hitherto humid, maritime climate became dry and continental, desert winds covered the fertile clay with a layer of sand, the soil became poorer and less productive, and the scarcity of food forced large sections of the comparatively dense human population to emigrate. Such emigrations had also taken place prior to that event, but hardly ever on such a gigantic scale as after the terrible disaster of the "flood."

Whether the Semitic peoples parted from their old homes before or after that event is not known; but, however this may be, the Zebu cattle evolved their steppe characteristics only after the emigration of the Semites.

Judging from the present occurrence of their domestic animals, the Semites wandered from the steppes of Asia Anterior eastwards over the southern parts of Iran to India and Southern China, whither they brought the Zebu. Towards the West they occupied Mesopotamia, Syria, Palestine and Arabia, whence they crossed over to Africa. Even today true descendants of Zebu cattle, red and parti-colored animals with long legs and small humps, are found along the ancient migration route of the Semites from Asia Anterior to Africa.[2]

The Zebu cattle and the fat-tailed sheep of the Semites did not penetrate into Africa from the North through the Isthmus of Suez, but from Bab el Mandeb, the most southernly point of Arabia, by way of Ethiopia. From Ethiopia the Zebus spread over the whole of the African continent.

It is not known at what period the Zebus first entered Africa. At the time of the "New Kingdom" large numbers of them appear to have already been in Egypt, having come via Ethiopia. I cannot agree with Antonius' opinion that the Zebus did not reach Southern Arabia and East Africa before the Christian era; a picture of Zebus, dating from the period of the "New Kingdom," disproves this assumption. I am of the opinion that the penetration into Africa by Semitic nomads and their Zebu cattle and fat-tailed sheep commenced during the second pre-Christian millenium, perhaps even earlier. Stanley asserts that for five thousand years Ethiopian tribes descended with their herds of Zebu cattle and fat-tailed sheep from the highlands of Abyssinia to the South in search of pastures and, by their mixture with the aboriginal population of Africa, gave rise to numerous races of a higher standard.[1]

Whilst part of the originally long-horned Zebus lost this peculiarity as a result of inter-breeding with short-horned cattle (*Bos taurus brachyceros*), with which they came into contact in India whither the Zebus were brought by the Semitic nomads from central Asia an opposite fate befell those Zebus which had come from Arabia to Africa.

Influence of the Longhorns

In Africa the Zebus came into contact with the long-horned Egyptian cattle which had accompanied the Hamites on their migrations towards the West and South. This meeting has had a far-reaching effect upon the African breeds of cattle. Descending from the highlands of Ethiopia the Zebus and fat-tailed sheep of the Semites either completely superseded the long-horned cattle and thin-tailed sheep of the Hamites, or else changed them to a greater or lesser extent. As far as the cattle were concerned, such changes mainly affected the length of the horns and the size of the hump.

In ancient Egypt, horn gigantism in cattle was unknown, nor is it known to occur in Zebus. But on a skull of the African Urus (*Bos primigenius* Hahni), the ancestor of the original cattle of the Hamites, Hilzheimer has ascertained such gigantism of the horns. The length of the left horn core was 35 inches and the circumference at the base, 15 inches.[1]

Abyssinia has to be regarded as the birthplace of the giant-horned cattle breeds of Africa, which spread, in a south-westernly direction, to the Central African lake district and southern Africa, and, westwards, between the north African desert and the primeval forests of the Congo to Lake Chad.

It is probable that the crossing of the long-horned Zebus with the cattle of the Hamites resulted sporadically in an atavistic mutation whereby the horn gigantism of the African Urus (*Bos primigenius* Hahni) reappeared. Such atavistic mutations are by no means rare occurrences in our domestic animals. In another breed of cattle whose origin can also be traced back to the long-horned cattle of the Hamites, namely the Franqueiro breed of Brazil, descended from Portuguese animals, such gigantic horns have resulted through mutation.

In Africa the expansion of this horn gigantism spontaneously appearing has been insured by the owners of animals so favored who selected and preferred them for breeding purposes. But even in pure-bred herds of giant-horned cattle, there are born from time to time animals whose horns do not exceed those of the common Longhorn cattle in length.

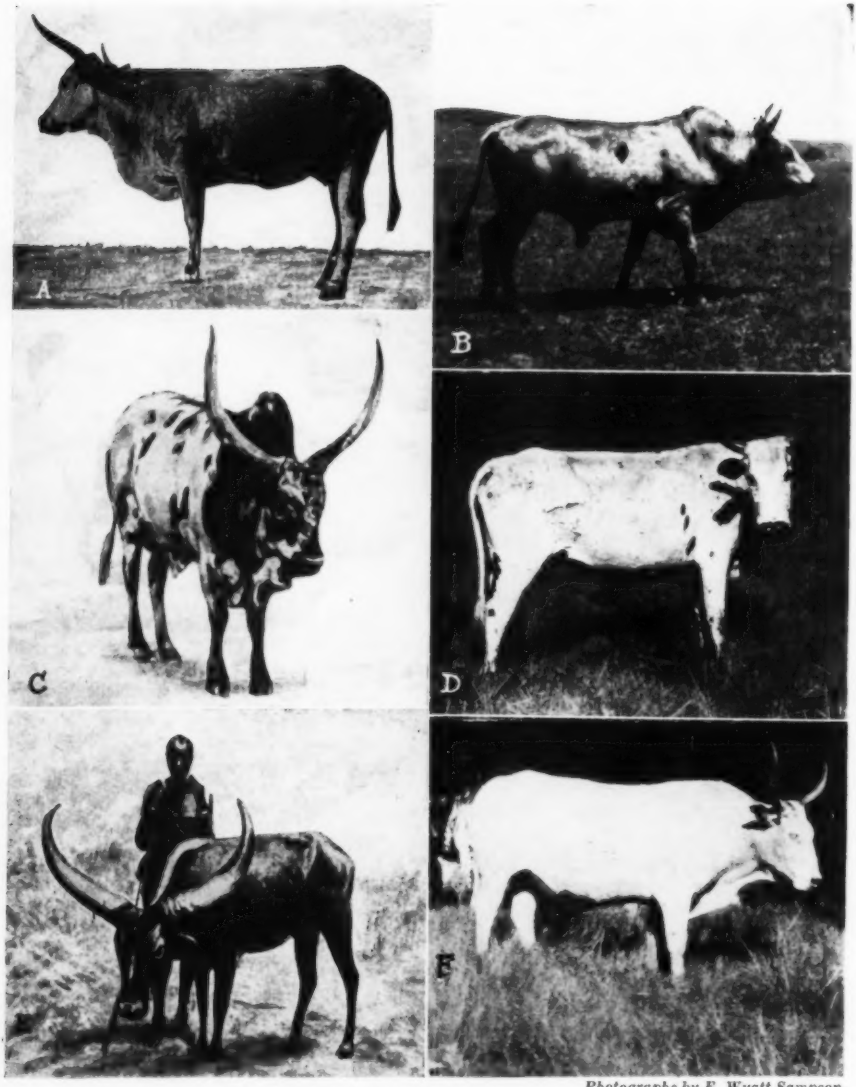
The hump, which appears in African cattle even more frequently than do gigantic horns, has to be viewed in a different light. Whilst the one phenomenon must be regarded as an atavistic mutation to which the impetus was given by the crossing of Hamitic cattle with Zebus, the hump is simply a result of cross breeding.

The same result of variation as is obtained from the F_2 generation onwards by crossing thin- and fat-tailed sheep is apparent in the formation of the hump in most African breeds of cattle, especially those of the Bantu peoples. According to the degree of the infusion of Zebu blood into the Hamitic cattle of Primigenius type, the hump is developed to a different extent, or is often entirely absent, and even in animals of one and the same breed some with large and others with only slightly developed humps are to be found.

While the hump and gigantic horns point to the influence of Zebu blood on the Longhorn cattle of the Hamites, a number of breeds are to be found in East, Central, and Southern Africa in which no trace of Primigenius blood can possibly be detected, but which must be regarded as pure Zebus, though in some of these breeds the hump has almost entirely disappeared. However, the hump is by no means a feature essential to all Zebus. Being merely an adaptation to steppe conditions, it often disappears in an environment in which it has no survival value. Just as in Africa, there are also numerous humpless Zebu breeds in Asia.

On the northern coast of Somaliland, Zebus have completely superseded the original cattle of the Hamites, and towards the South down to Lake Victoria various native tribes are found in possession of pure Zebus. From there the migration of the Hottentots to Southwest Africa and to the Cape started. From that region they brought their cattle and sheep.

While the Zulu, the Bechuana, the Watussi, and Damara cattle represent breeds originating from a mixture of Hamitic Longhorn cattle of Primigenius type with Zebus, animals which still preserve the characteristics of *Bos primigenius* in the osteologic conditions of their skulls, though horn gigantism does not exist in the Zulu and Damara breeds, the cattle of the Hottentots and

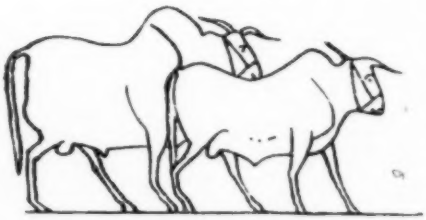


Photographs by E. Wyatt Sampson

OTHER AFRICAN BREEDS

Figure 4

Types of African cattle of Hamitic and Longhorn ancestry showing the marked difference between these breeds and the Hottentot cattle. *A*—Damara Cow (after Schlettwein); *B*—White Zebu Bull; *C*—Watussi Bull (after Adametz); *D*—Zulu Cow; *E*—Watussi Cow (after Adametz); *F*—Zulu Ox. These breeds show some Zebu characteristics such as the hump (*B*) and (*C*) which indicate that they have an admixture of Zebu blood. The gigantic horns (*E*) are characteristic of the Hamitic Longhorn breeds and are not found among the Afrikander cattle.



ZEBU CATTLE OF THIRTY-FIVE CENTURIES AGO

Figure 5

Egyptian drawings of Zebu cattle dating from the new kingdom (about 1500 B. C.). There can be little doubt that these cattle represent a Zebu type which is believed to have come into Egypt through Abyssinia. From the same source it is very probable that the cattle of the Hottentots originated.

their offspring, the red Afrikander, are a pure Zebu breed.

Molhuysen[9] in describing the skulls of a number of Afrikander cattle has pointed out their similarity to the osteologic conditions of Zebu skulls.

Characteristic for the skull formation of all Zebu cattle are the great length and small breadth of the head, the comparatively long, narrow and clean-cut muzzle, the slight prominence of the eye brows, and the convex profile, although the last-mentioned factor is not very constant and in some Zebu breeds completely absent.[1]

The molar teeth of the red Afrikander cattle are placed in an oblique position just as in other Zebu breeds, the structure of the enamel is simple, the course of the grooves little complicated and the enamel strongly developed. The back part of the lower jaw bone ascends vertically in the red Afrikander as well as in other Zebu cattle, and many other characteristics of the bones of the skull, by which these animals differ from cattle of Primigenius type, are common to all.

There is another important feature which proves that the Afrikander cattle must be regarded as true Zebus. All Zebu breeds are distinguished from other species by the shape of the spinous processes of the dorsal vertebrae the tips of which are deeply cleft. The same phenomenon is found in the vertebrae of the Afrikander cattle, but there is hardly even a suggestion of such a fissure in cattle of Primigenius type.

Certain similarities between the skulls of the Watussi and red Afrikander cattle are to be accounted for by two facts. Molhuysen has ascertained that the Watussi cattle and many other African breeds have their origin in a cross between a Zebu strain and the cattle of the Hamites. Furthermore *Bos Namadicus*, the ancestor of the Zebus, must have been a form which was not distantly related to the Urus, the ancestor of the Hamitic cattle.

Afrikander a Zebu Breed

At all events the cattle of the Hottentots and the red Afrikander belong to the Zebu group. It is even probable that the original characteristics of the Zebu cattle are here preserved in a purer form than in the Zebus of Asia which, as Stegmann asserts, have been exposed to the influence of short-horned breeds.

That there is a similarity between the Afrikander cattle and the Zebus which were brought by Semitic nomads from Abyssinia to Egypt and other parts of Africa 3,000 to 4,000 years ago, as regards the form and direction of their horns and all important characteristics of the body, is shown by an ancient Egyptian picture of Zebus, dating back to the period of the "New Kingdom" (Figure 5).

It is not definitely known when the Hottentots first came into possession of their Zebu cattle and fat-tailed sheep. It is probable that they received their animals at a later period than did the Nilotic and Bantu tribes, whose cattle have the old breed of the Hamites as a foundation, at a time when Zebus were imported into Africa in such large numbers that the breed was preserved in its pure form. Importa-

tions to such an extent probably only took place in post-Christian eras, in any event not earlier than during the last centuries before Christ.

The fat-tailed sheep of the Semites, the descendants of the Asiatic *Ovis arkal,* probably entered Africa at the same time as the Zebus, i. e., from about 2000 B. C. onwards. Because of their wool and the fat deposits in their tails they completely replaced the thin-tailed sheep of the Hamites in Egypt. But descendants of the latter are still to be found amongst the inhabitants of the Sudan and the Bantu tribes of the east coast of Africa. The sheep of the Zulus and of the Bantu peoples further north were originally also of the long- and thin-tailed type.*

With only one exception, the fat-tailed sheep of the Semites, which subsequently lost their wool under the tropical conditions of Central Africa, did not penetrate far to the South. But this exception is the more interesting as it forms such a complete counterpart to the history of the Zebu cattle of the Hottentots. This concerns the fat-tailed sheep which wandered with the Hottentots to Southwest and South Africa.[1] Wherever they came into contact with the thin-tailed Bantu sheep, they replaced these. Thus the Hereros, the Bechuanas and the Bantu tribes in their neighborhood, who originally only kept thin-tailed sheep, commenced breeding fat-tailed sheep as soon as they encountered the Hottentots.

That the Zebus and fat-tailed sheep of the Semites were preserved amongst the Hottentots for so many centuries in their original pure form is due to the fact that the Hottentots were one of the most southern African races of partly Caucasian origin. Therefore they were able to withdraw from any pressure from the north and move to the south where no pastoral tribes, but only Bushman hunters, dwelt. During their migration to the Cape, their herds of Zebu cattle and flocks of fat-tailed sheep were removed from any foreign influence, until, at the most southern part of the Continent, they met the vanguard of the Europeans.

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*Information supplied by Prof. H. H. Curson Onderstepoort, Pretoria, South Africa.

BRICKS WITHOUT STRAW

A Review of "The Eugenic Predicament"

J. H. KEMPTON
Bureau of Plant Industry

WE are in the midst of a "new deal" in our economic life with every effort being made to devise a commercial system that will give a wider distribution of wealth and insure a less burdensome existence to the many. With such an end in view it is certainly the part of wisdom to consider the biological composition of the population whose economic condition it is intended to improve. Clearly the extent to which governmental paternalism must be developed to provide health, wealth and happiness for everyone will depend in a large measure on the ratio of imbeciles to intelligent beings. Further, if the intellectual level of the population is falling this fact should be taken into account in the long range economic planning about which we hear so much. While this will not be done by our present planners the time is coming when we shall have to give more attention to these questions and every well-informed person should keep abreast of all matters that concern humanity.

Chief among these human biological problems is human heredity, widely known under the name "Eugenics." For reasons which need not concern us here this subject has become almost wholly discredited in the public mind. Even now it is entering another period of questionable publicity as Herr Hitler attempts to compel his followers to adopt his standard of the German breed and to close the national stud to all who depart from the set type.

Although men like Hitler subject Eugenics to further ridicule their antics stimulate a demand for information on the subject of human heredity that may, in the end, prove beneficial.

There is no dearth of books on Eugenics to satisfy inquiring minds, though most of them are special pleading of one sort or another. The latest treatise on this subject, and one that justly can be classed as very special pleading, is *The Eugenic Predicament* by Prof. S. J. Holmes.* Professor Holmes is frankly a Eugenicist in the sense of recognizing a deterioration of humanity that can be corrected by appropriate application of the laws of heredity. The title is well chosen as the reader will discover. It is one thing to appreciate that laws of heredity, worked out for the lower organisms, apply also to man, but it is quite another matter to devise a workable scheme for applying this knowledge.

The book is divided into seven chapters and has an appendix, a list of references and an index. It is pleasingly printed and lucidly written. The author wastes no time in acquainting the reader with the intricacies of Mendelian inheritance, but moves directly to the subject of the inheritance of mental qualities. Now it is in just this field that the science of human heredity is weakest and there are no direct analogies with known facts in the lower orders of life. In consequence there is a tendency among writers on Eugenics to anesthetize their critical faculties and utilize data on the inheritance of mental capacity that, in a genetic experiment, would not even be considered worth recording. Professor Holmes is no exception to this practice.

Perhaps it would be safe to say

*HOLMES, S. J. The Eugenic Predicament. pp. 232. $4.00. Harcourt, Brace & Co., New York, 1933.

that no geneticist doubts the inheritance of mental capacities, but few would care to be dogmatic with respect to particular cases. In an organism where mating is not under the control of the investigator, and where ancestry is largely unrecorded, only very generalized deductions can be made and, when there is added to these unknowns the admitedly imperfect estimation of the degree of intelligence, the difficulties are great indeed, yet when it comes time to do something about mental capacity, from a procreational standpoint, it is individual cases that must be dealt with.

Professor Holmes canvasses the statistical analyses of the ancestry of idiots, imbeciles and morons and concludes that the inmates of our institutions for these unfortunates are there largely because of their defective heredity. This position is sustained, in the author's opinion, by comparisons of the I Q's of siblings wherein correlations ranging from .39 to .5 were found and where the siblings of children testing from 135 to 190 had an average rating of 129. We confess taking malicious delight in his pilloring of the environmentalists. "The environmentalist has never shown that the production of intelligence of this order out of average mentality is even possible;" but where then do the environmentalists think children with I Q's of 190 come from?

In the discussion of a report by Dr. A. C. Williams on the parentage of the mentally deficient pupils in the special schools of London, on page 44, it is stated "A rough classification of the mental grades of the parents gave the following percentages: superior or above average ability, 15 per cent; average ability, 45 per cent; inferior ability, 28 per cent; mentally defective, 4 per cent . . ." Quite aside from the fact that this leaves 8 per cent of the children as purely synthetic products one wonders how it happens there was such a perfect sexual selection among these parents. In real life one would expect occasional families where the parents were of dissimilar mental capacities.

However, Professor Holmes has other strings to his bow. He assembles the cases of identical twins afflicted with feeble minds. Altogether he discusses 65 sets of identical twins of which in 60 sets both members were feeble-minded whereas in the remaining five only one member in each case was affected, the other being normal. For two of these latter cases the author offers the explanation "In these 2 cases one twin may have been made feeble-minded as the result of a birth injury or some other extraneous cause." This explanation seems to be based on nothing more tangible than that these identical twins were not identical in mental capacity. Doubtless the explanation is justifiable but it rather robs this line of investigation of convincing weight. Among non-identical twins where one or more members of the pair had mental defects he found thirty-four sets where both members were afflicted and 83 sets where one twin was normal, or had a type of mental defect entirely different from that of its mate.

These arguments have become familiar to readers of Eugenic literature (which, of course, is nothing to their discredit) but this line of reasoning is open to serious objections, and in fact since siblings have similar environments the data can be used almost as effectively to prove that their similar mental capacities are due solely to environment.

In his utilization of this information Professor Holmes comes close to arguing his case, to quote his own words: "not like a scientist endeavoring to get at the truth, but like an attorney striving to make a strong impression on the jury; and the various arts appropriate to the later function he has employed with his customary adroitness," which illuminates the pitfalls awaiting the scientist with a cause.

Not the least entertaining chapter in the book is entitled "Eugenics and Its Critics." Here Darrow, Pearl and Jennings are administered summary punishment in a thoroughly good-humored manner. "Our scrutiny of the passage quoted from Doctor Pearl discloses the fact that most of the statements are either untrue, half true, or in some respects misleading" or speaking of Clarence Darrow—"He has worked himself up and let himself go, with the result of producing an impassioned diatribe, full of misconceptions, misstatements and half-truths, which may be very well suited to impress the jury, although they would have little effect upon a discerning judge." Clearly Prof. Holmes has a felicitous style.

We can agree with the author that "we should all like to see the race freed from its hereditary feeblemindedness, epilepsy, insanity and the many weaknesses and defects that cause life to be a burden . . ." In fact we can go further than this for almost every one would like everything to be better. The question is simply how to proceed to attain this perfection.

If we grant that for the most part like reproduces like so far as mental capacity is concerned (though this is granting a great deal) and admit that brilliant parents at times give birth to a dull offspring we can take up the question as to what to do.

Now there are almost as many ideas as to what should be done to improve mankind genetically as there are schemes for restoring prosperity. One large and conservative group of geneticists is wholly unwilling to do anything because of the woeful lack of definite knowledge. Another group advocates sterilization, or at least the prevention of procreation, of idiots and imbeciles. Such a program is not unreasonable but even the most ardent champions of this treatment admit that its beneficial effects are slight and slow. We could not devise a more effective sterilization than death before two years of age, such as occurs with amaurotic idiocy. Yet such afflictions have not been self eliminating and they still persist in spite of the drastic natural sterilization.

A third group, not composed wholly of geneticists, envision the millenium through birth control. It is only necessary, so the advocates of this method believe, to encourage more births among the better element and fewer births in the lower brackets. Although there is every reason to suppose that the lesser intellects are having more children than are the greater minds, the fact has never been incontrovertibly demonstrated, for so soon as the question is raised we are faced with such problems as are farmers more, or less, able than lawyers and are not both these groups inferior to professors and bootleggers? The difficulties inherent in choosing the progenitors of the next generation have been well expressed by another puzzled soul:

> God bless the King!
> I mean the faith's defender.
> God bless—no harm in blessing—the Pretender
> But which Pretender is, O which the King
> God bless my soul—that's quite another thing.

Pearl maintains, in a study of the ancestry of the world's distinguished philosophers, that petty office holders, shopkeepers, lawyers, clergymen, college professors, physicians, farmers, weavers, lawmakers and plain titled persons, to say nothing of fishermen, saddlers, schoolmasters and historians, are merely mediocre. Holmes, on the other hand, holds that these same people are distinctly above the average and might be expected to give rise to a philosopher now and then as indeed they have done, as a matter of historical record! However it hardly seems fair of Professor Holmes to consider these people above average when it comes to engendering philosophers, but distinctly below average when it is a matter of a differential contribution of offspring

to the population. In developing the case for unequal fertility of the lower orders Professor Holmes presents a table from the U. S. Registration Area for 1928 in which, among others, agricultural fathers are shown to have 3.5 living children; tradesmen 2.4 children, professional service 2.1 children and clerical 2.0 children. This is held to be fairly good evidence that the next generation is being derived from the lower elements of our society! These problems are not convincingly solved by logic, and until they have been settled, statistical analyses of family size based on occupational groupings will mean practically nothing from the standpoint of applying Eugenic principles to the improvement of human beings.

Progress through differential birth control will surely be difficult to measure until a more certain standard of excellence is available. Nor should we lose sight of the fact that it will not be a simple matter to achieve limited families among the ignorant by means of common contraceptives. Such evidence as exists shows that the women of lower intelligence have more children when contraceptives are used than when nature is permitted to take her unobstructed course!*

Then there are various proposals for family bounties, the higher the mental capacity the more allowance per child. The political possibilities of this plan are attractive enough to almost insure it a trial; but all these solutions ignore the same unknown quantity and are wholly lacking in practicability.

Another proposal, and one of some merit is to increase the standard of living among the poorer classes until the advent of a child in this group is as much of a calamity as is a similar "blessed event" among the gifted. Once this condition had been established the birth rate in all classes should be uniformly low. If all goes well with the New Deal this method may soon be put to test.

Still another way out, hopefully suggested, is to accentuate sexual selection. When we consider all the hereditary deformities and the general ugliness still with us, and recall that every maiden has envisaged a Prince Charming, to say nothing of every swain having anticipated at least a Mae West (or her equivalent) since the beginning of history, we can evaluate the improvement to be expected from more sexual selection. It just won't work with humans burning with a procreational urge, and what the others do hardly matters.

In final analysis, and not wholly unexpectedly in a professor, the author places his chief reliance for a better future population in education. It can not be denied that this conclusion is entirely sane and certainly should be tried for all its worth, but educators are going to discover a lamentable lack of unequivocal information to impart. After all, what humanity really needs is a thorough knowledge of human heredity and we are not extending this knowledge at a rate rapid enough for our own good. If books on Eugenics succeed in demonstrating this defect they will have served their most useful purpose.

It would not be fair to the author's high-minded purpose, nor to his excellent accomplishment, to close this review on an expostulatory note. It is not Professor Holmes' fault that the Science of Eugenics is not further advanced. He has made out a good case for his beliefs and entertains no illusions as to the difficulties in the way of improving on the Lord's images. The purchaser will find a thoroughly readable book and should gain a better understanding of the complexity of the problem.

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LIGHT-PHASE MALLARD DUCKS

R. GEORGE JAAP
*University of Wisconsin**

IN a previous paper,[3] a series of three allelomorphic genes which produce differences in the plumage pattern of Mallard ducks has been reported. The study herein reported is an analysis of the inheritance of a light color phase which interacts with the "mallard" allelomorphs to produce further variation in the plumage. Particular attention is given to the differences in expression of sexual dimorphism resulting from the interaction of these genes in the mallard male.

Allelomorphs of Mallard Plumage

The phenotypic expression of the Mallard allelomorphs in each of the dimorphic areas of the sexual plumage of the male may be briefly reviewed here. The characteristic color of the Mallard male in each of five dimorphic regions is as follows: (1) neckring, white; (2) anterior part of the breast, claret-brown; (3) remainder of the breast, gray pencilled; (4) dorsal wing surface, ashy gray; and (5) ventral wing surface, white. The gene which produces these colors in the above mentioned regions is designated as "mallard," with the symbol *M*. Variant patterns are described by the manner in which they differ from this type. Males with the dominant member of this allelomorphic series, "restricted" (M^R), differ from mallard only in the presence of white-spotted feathers on the dorsal wing surface. The dusky (m^d) pattern, which is recessive to both M^R and *M*, eliminates the sexual white neckring and claret-brown color of the breast, and changes the ventral wing surface to stippled gray.

Adult "Light-phase" Ducks

"Light-phase" is another recessive mutation from the normal color. Its action on the mallard allelomorphs produces a lighter color, as well as more pronounced differences in pumage dimorphism. This lighter color is more readily observed in the female, in which it produces a much lighter color tone (Figure 6, *C* and *D*). Light-phase is named from this effect and is designated by the symbol, *li*.

These "light-phase" females have been described previously by Rogeron[7] and Finn.[1] Both writers have also observed a type of male in which, to quote Finn, "the claret-brown of the breast is carried along the flanks and occasionally onto the shoulders." The color of the back in these males is somewhat lighter than the normal type. Finn observed one of these males after it had grown the somber, female-like feathers of the "eclipse" or summer plumage. At this time it had a color similar to that of the light colored female. The results presented in this paper demonstrate that males of this type (Figure 6 *F*) are genetically "light-phase" and homologues of the light colored females described above.

Light-phase Ducklings

As a result of careful observation of the progeny of an original pair of light-phase ducks, and comparison of these with ducklings from other mallard matings, it has been found possible to distinguish dark- and light-phase ducklings at any time after about 19 to 20 days of incubation. Light-phase is differentiated by an absence of dark

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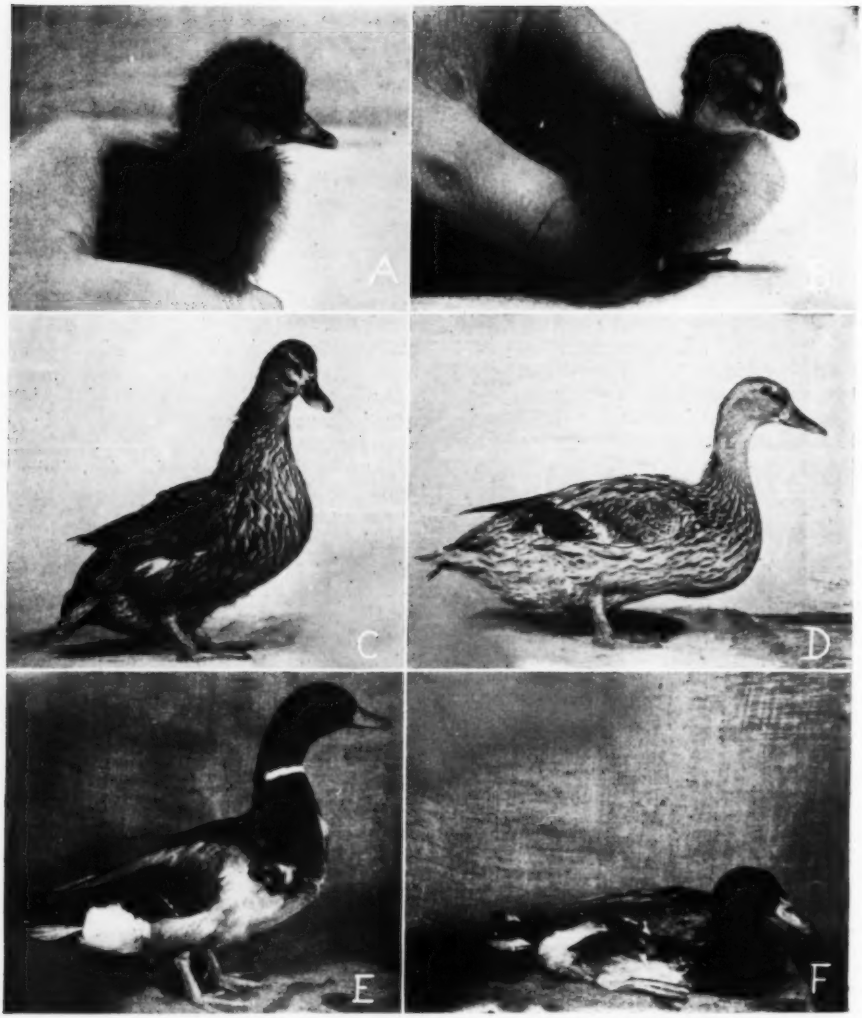
DARK-PHASE LIGHT-PHASE



"DARK-PHASE" AND "LIGHT-PHASE" MALLARD DUCKS

Figure 6

The mallard pattern is controlled by two main factors designated *M* and *Li*. A recessive mutation of the *Li* gene (*li*) produces (in the presence of the *M* gene) a lighter plumage color and other typical differences. Above are shown the juvenile and adult forms of the two types. The normal mallard duckling can be distinguished from the light-phase form by the two ocular stripes (*A*). The "light-phase" form has but a single ocular stripe (*B*). In mature females the *li* gene brings about a reduction in the size of the dark portion of each feather, producing a lighter tone of plumage (*D*) than the normal mallard (*C*). In the male the "light-phase" form (*F*) is characterized by the extension of the claret-brown color along the sides of the breast below the wing, which is lacking in the mallard (*E*). It is interesting that a gene which produces a general reduction in color in the female should produce in the male an *increase* in pigment in this region.

color in an area on the breast. In dark-phase ducklings, the entire breast, from the neckring region to the tail, has a dull undercolor ranging from black to slate. In light-phase, the non-pigmented area in the breast varies from a patch one or two centimeters in diameter, to an area which covers most of the breast. Since but a limited number could be raised to maturity, the duckling classification is used for the ratios.

Light-phase ducklings never have more than one dark ocular stripe (Figure 6 *B*). While dark-phase ducklings usually have two (Figure 6 *A*), they occasionally have only one stripe, and accordingly this character cannot be used for separation of the two types.

Breeding Results

Semi-domesticated mallard stock was used to analyze the inheritance of light-phase. This consisted of birds reared by the Poultry and Genetics Departments of the University of Wisconsin, and one light-phase female which was secured from a small flock in the vicinity of Madison. The inheritance of light-phase was tested with birds homozygous for mallard, *MM*. This was necessary because its phentoypic expression on the other two patterns, restricted and dusky, was not known in the early part of the study.

The results of these matings, within the Mallard variety, are presented in Table I. Those matings included in part (*a*) are paired matings of light-phase ducks. The parents in these six matings involve 10 different light-phase individuals, 5 males and 5 females. The birds used in matings, 4, 5, 16, and 25 were present in the stock when these studies were undertaken, while those in matings 57 and 64 are light-phase segregates. Since five of the matings produced 100 light-phase ducklings only, the presence of one exceptional dark-phase individual in the progeny of mating 25 is probably due to an error in the records or in classification.

Matings of homozygous dark-phase Mallards are given in part (*b*) of this table. The 212 ducklings produced from these matings were all dark-phase.

In part (*c*) matings 20, 35, and 37 are pairs of dark-phase ducks which produced some light segregates, while the parents in matings 44, 46, and 49 are dark-phase segregates from backcross matings and are therefore, necessarily heterozygous. The total of 130 dark- to 44 light-phase progeny accords with expectation.

Further confirmation of these results is shown in part (*d*) of this table, in which heterozygous dark-phase individuals are backcrossed to the recessive light-phase. Matings, 22, 27, 30, and 34 include those in which the male is

TABLE I. Summary of Light-Phase Matings

	Mating No.	Type of mating male x female		Offspring Li	Offspring li
(a)	4	li li	li li	0	24
	5	"	"	0	40
	16	"	"	0	20
	25	"	"	(1)	12
	57	"	"	0	13
	64	"	"	0	3
Total				(1)	112
Expected				0	113
(b)	9	Li Li	Li Li	92	0
	75	"	"	39	0
	76	"	"	80	0
Total				211	0
Expected				211	0
(c)	20	Li li	Li li	24	8
	35	"	"	20	12
	37	"	"	9	4
	44	"	"	28	5
	46	"	"	27	9
	49	"	"	22	6
Total				130	44
Expected		(3:1)		130.5	43.5
(d)	22	Li li	li li	16	35
	27	"	"	8	1
	30	"	"	11	10
	34	"	"	9	5
Total				44	51
	48	li li	Li li	19	11
	51	"	"	13	8
	56	"	"	8	13
Total				30	32
Total backcrosses				74	83
Expected backcrosses (1:1)				78.5	78.5

A DARK-PHASE MALLARD DUCKLING

Figure 7

When a mallard duckling is newly-hatched the color tone of its adult plumage can be predicted. The duckling shown above will have the plumage color which is designated as "dark-phase." The "dusky" form (m^d) is uniformly dark in color. (See cover illustration.)

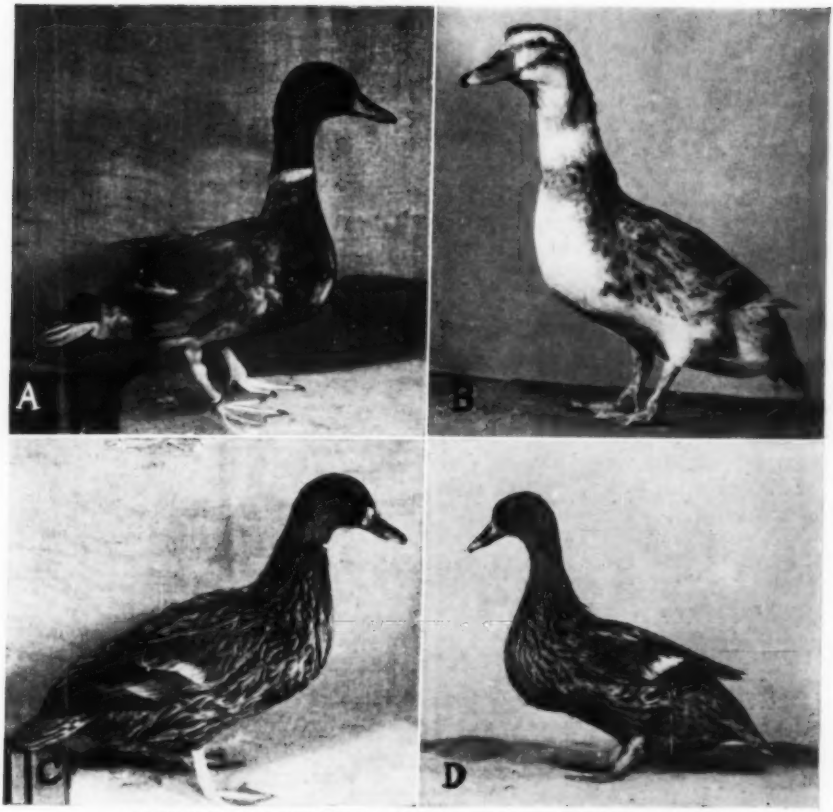
the heterozygous parent. The totals of 44 dark- to 51 light-phase ducklings from these matings approach the expected 1:1 ratio. The reciprocal of these crosses, light-phase males with heterozygous dark-phase females, produced 30 dark to 32 light-phase individuals. The results from matings within the Mallard variety, therefore, confirm the hypothesis that light-phase, *li*, is a simple Mendelian recessive to dark-phase, *Li*.

Variation Produced in Ducks by *Li* and *li* with M^R, *M* and m^d

In addition to the records here presented on the inheritance of light- and dark-phase, many other matings have produced some light-phase segregates. A few of these are matings within the Mallard variety which segregated for dusky. The others are from various hybrids of the White Pekin and Black East India varieties when crossed with the Mallard. All of these matings segregated for other color types, which made it impossible to classify a part of the newly-hatched progeny. For example, it has been impossible to distinguish light- and dark-phase on dusky, m^d ducklings. They are probably somewhat lighter, but no definite line of demarcation can be drawn between the light- and dark-phase types.

Another color type which obscures the phenotypic expression of light-phase in the young duckling is the sex-linked olive brown pattern analyzed by Punnett[5, 6], and Walther, *et al*[8]. This color shade confuses classification by making the undercolor of the breast so light that, in some cases, it is impossible to distinguish the non-pigmented breast area of light-phase. However, when these ducklings are raised to maturity, the dark and light phases are readily distinguishable.

There is considerable variation in both the light and dark types. Owing



ADDITIONAL EFFECTS OF THE "LIGHT-PHASE" GENE

Figure 8

A recessive allelomorph of the mallard gene (*M*) designated m^d produces "dusky" plumage. Examples of the effect of "light-phase" on this plumage are shown above (*A*, *C*, and *D*). The "light-phase dusky" male (*A*) has claret brown color on the anterior breast region. This is never present in the dark-phase dusky malt. The difference between "dark-phase dusky" (*C*) and "light-phase dusky" (*D*) females is not as great as the differences between these two phases when the mallard gene is present. (See Figures 6*C* and 6*D*). In the "light-phase mallard" female (*B*) the dark color has been inhibited probably by modifying genes.

to the light color tone, this variability is more noticeable in the light-phase. As observed by Punnett,[6] a very light type occasionally occurs (Figure 8*B*). As adults, these have a large white collar and a creamy white breast. The presence of extremely light-colored individuals is probably due to some modifying genes acting on light-phase.

The description of light-phase adults given at the beginning of this article is for those individuals which are phenotypically mallard, *M*. The changes produced by *li* in restricted (M^R) are similar to those in mallard and need not be discussed further. In dusky (m^d), a lighter color tone is noted in some of the light-phase females but, when compared with dark-phase dusky (Figure 8*C*), the difference is not as pronounced as it is in mallard or restricted.

The effect of *li* on the dusky male is interesting and helps to explain some of the confusion prevalent in the earlier

literature. In the dark-phase dusky male, the gray of the breast extends forward to meet the iridescent black of the head and neck. Contrasted with this lack of claret-brown on the breast of the dark-phase dusky, the light-phase dusky male always has some claret-brown in the anterior breast region (Figure 8*A*). The claret area varies in size but is always smaller than that found in the dark-phase mallard.

The dark-phase was the only type of dusky ("freak") male obtained by Phillips,[4] and from his description of the mallard pattern it appears that he did not have light-phase in his stock. Goodale[2] obtained two dusky males in the F_2 generation of Pekin-Rouen crosses, as indicated by the presence of a pigmented ventral wing surface. Claret color was lacking on the breast of one of these; the other had the claret area and was presumably light-phase. Finn[1] states that "chocolate" may appear at the base of the neck of an otherwise gray-breasted bird. Assuming that some of the dusky males had the non-sexual types of white neck-ring, the types of individuals previously recorded in the literature are explained by the interaction of *Li* and *li* with M^R, *M*, and m^d.

The gene *li* produces a lighter color in the juvenile feathering, in the adult plumage of the female, and in the "summer" plumage of the male, by a diminution of the size of the dark portion of each feather. In the dimorphic male plumage, light-phase increases the size of, or produces in the case of dusky, a claret-brown region. The accompanying chart may aid in visualizing the difference produced by the genes *Li* and *li* interacting with the allelomorphs, M^R, *M*, and m^d:

Gene combinations	Phenotypic variation of the dimorphic plumage areas of males, as compared with the generally accepted wild mallard type, *M Li*.
M^R	*Li*—white spotted feathers on the dorsal wing surface.
	li—white spotted feathers on the dorsal wing surface; claret-brown along the sides of the breast.
M	*Li*—"Wild type."
	li—claret-brown along the sides of the breast
m^d	*Li*—absence of claret-brown on the breast; absence of sexual white neck-ring; stippled gray ventral wing surface.
	li—absence of sexual white neck-ring; stippled gray ventral wing surface.

Summary

1. The effects of a recessive gene, *li*, which produces a light color phase in "mallard" ducks, are described.

2. "Light phase" can be distinguished in the newly-hatched mallard duckling or even in those which die in the shell.

3. In the juvenile feathering, in the adult plumage of the female, and in the "summer" plumage of the male, the gene *li* produces a lighter color tone in individuals that are genetically restricted (M^R), mallard (*M*), or dusky (m^d).

4. Light-phase on the dimorphic male plumage of restricted and mallard is distinguished by an extension of the claret-brown color along the sides of the breast.

5. The wild type is considered to be dark-phase mallard, *M Li*.

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A STUDY OF IDENTICAL TRIPLETS

Part I. Comparison of the Physical and Mental Traits of a Set of Monozygotic Dichorionic Triplets

L. W. SONTAG* and V. L. NELSON*

THEIR FRIENDS CAN'T TELL THEM APART

Figure 9

Fred, John, and Henry at twenty-three months of age. They are so much alike in general appearance that even when they were a year older it was necessary to stand them up side by side to tell which was which, for fortunately they differ slightly in height. There are other convincing evidences that they are identical triplets. Their birth membranes are unquestionably dichorionic.

SINCE the latter part of the nineteenth century, scientists have recognized the possibilities of studies of monozygotic twins and triplets as a means of throwing light on the heredity-environment controversy. Because in man we are denied the opportunity of producing genetically uniform strains by continuous planned inbreeding, a study of identical twins and triplets offers the most satisfactory way of estimating the relative importance of these two factors in human development. During the last six or seven years, the literature dealing with the subject of uniovular multiple births has contained reports of several sets of

*Members of the staff of the Samuel S. Fels Fund for research in prenatal and postnatal environment, located at Antioch College, Yellow Springs, Ohio.

monozygotic triplets. Komai and Fukuoko,[2] Clarke and Revell,[1] Sanders,[3] and others have presented studies containing careful comparisons of the physical and mental characteristics of such triplets.

The staff of this institution has had under its observation a set of boy triplets now four years of age, of uniovular origin. A detailed study of these children has been made, in which special attention has been given to differences in their behavior and in their environment. Physical and mental traits of the children have been recorded and analyzed also.

In many respects these triplets have offered unusual opportunities for research in the field of behavior differences. Their parents are highly cooperative; the children are readily accessible to members of the Fels staff. Observations on the trio have been made regularly at least once a month for as long as half a day at a time in the home environment. Up to the present time, these observations have extended over a period of thirty months, and it is planned to continue them as long as it seems desirable. This is particularly important. One may obtain body measurements of children, compare their hair and eye color, skin, etc., and make estimates of mental development in a comparatively short time. However, if a comparison of their behavior is desired, it can only be obtained through long hours of periodic examination. Likewise, while it is possible to obtain a history of illness, nutrition, and family life in a few minutes, only prolonged observation can yield accurate knowledge of the emotional atmosphere of a home, of alliances between children and parents, and among the children themselves, and of the relationship with neighbors and others outside the home who may have contact with the children.

Because of the amount of material to be presented, it was felt best to divide the report of this study into two parts. Part I, the discussion included in this paper, contains a description of the birth membranes, and comparative studies of the physical and mental traits of the triplets—material which establishes the monozygotic origin of the trio. This information is prefaced by a brief description of the prenatal environment of the triplets, and a history of their birth. Part II of the report will contain sample observations of the activities of the triplets, and a discussion of their behavior differences and their postnatal environment.

Nature of Pregnancy

The triplets, Fred, John, and Henry, are the only children of their parents, who had been married about five years at the time of their birth. The mother was twenty-eight years old at the birth of the children and is of German extraction. The father also was twenty-eight years old, of German extraction, and a carpenter by trade. There is some history of twinning on both the paternal and maternal sides. The father's paternal grandmother was a twin and the mother's mother miscarried a pair of twin girls.

The pregnancy was rather a stormy one. At four months the mother began to suffer from increased blood pressure (138/72), oedema of the ankles, dyspnea and fainting spells. The urine showed no albumin. Because symptoms were suggestive of hypothyroidism, the patient was given Lugol's solution, a preparation containing iodin. A basal metabolic rate taken a month later showed no increased thyroid activity.

The patient was put to bed for a month, at the end of which time the symptoms began to subside. Physical examination showed more than one fetal heart sound. Multiple extremities were felt. X-ray showed the existence of three fetal heads and three spines. The roentgenologist

made the diagnosis of triplets, but could not be sure there were not four feti present. The mother made a total weight gain of about 15.88 kilograms and weighed 84.82 kilograms just before delivery.

Birth

The weights of the triplets at birth, given in the order of delivery, were as follows: Fred, 2,041 grams; John, 1,814 grams; and Henry, 1,559 grams. The birth membranes have been carefully preserved. While they are not in themselves conclusive evidence, they point strongly toward the uniovular origin of the triplets. There is a single placenta which is nearly round measuring 24 cm. by 25.5 cm. and weighing 1,332 grams. The membraneous surface is divided into three somewhat unequal parts by two membraneous septa. Dr. George W. Streeter of the Carnegie Institute of Embryology at Baltimore, who sectioned both membranes, reports:

> I have just been studying the sections of the two membranes which we cut out from your case of triplets. One of these consists of two amnia fused back to back. The other also shows two amnia, but between them is another layer, evidently a much reduced chorionic septum with here and there remnants of blood vessels.

The septum composed of two layers of amnia containing between them a layer of chorion, proves that the specimen is a dichorionic one. Examination of the placenta both by the authors and Dr. Streeter yields no indication of a fusion of two placentae. From the evidence of the membranes alone, then, the probability is that we are dealing with a dichorionic monozygotic birth. A subsequent study of the physical and mental traits of the triplets proved this to be the case.

Comparison of the Physical and Mental Traits

In comparing the mental and physical traits of the triplets with the object of establishing or disproving their uniovular origin, the outline devised for this purpose by Siemans[4] was used. It lists, in order of their importance, the traits to be compared, and the degree of similarity expected, if origin is uniovular. The outline follows:

A. Traits which agree in one-egg twins almost always and almost completely; in two-egg twins only rarely:
1. Hair color and form.
2. Eye color.
3. Skin color.
4. Downy hair of the body.

B. Traits which vary slightly in one-egg twins; and which usually vary more widely in two-egg twins:
5. Freckles (location of).
6. Appearance of blood in the skin (teleangiectasis, cutis marmorata, acroasphyxia).
7. Follicular processes (lichen pilaris, acne).
8. Tongue (furrowed or not) and teeth.

C. Traits in which one-egg twins usually, two-egg twins only rarely show strong resemblances to each other:
9. Form of face (physiognomy).
10. Form of ear.
11. Form of hands (and of nails).
12. Body build.

This scheme can be extended as desired, through the inclusion of other traits; the method is therefore capable of unlimited development. As additions one would especially think of:
13. Mental make-up (school standing, character, talent).
14. Illness and abnormalities.
15. Traits which are the bases of special methods of investigation (finger prints, microscopic comparison of the capillaries, refraction of the eyes, blood groups, etc.).

Applying these criteria to the triplets gives us the following information:

1. The hair of all three of the triplets is light in color. No difference can be detected in shade either upon examination of the heads of the children or upon examination of the locks cut from the three heads. There is no discernable difference in the texture of the hair or its form. All three boys have clockwise hair whorls situated slightly to the right of the midline.

2. Careful comparison of the eyes shows no appreciable difference in iris color. There is a mild strabismus convergens of about equal degree in all three. The mother gives a history of similar strabismus in childhood.

3. The color of the skin of the three triplets is alike. It is slightly darker than one would ordinarily expect to find with as light hair as these children have.

4. The downy hair of the body is of very similar appearance on all three. It is the same shade and each child has the same amount. The only perceptible difference is a clockwise lanugal whorl between the scapulae on Fred.

5. Close examination reveals no freckles on any of the three.

6. There is no telangiectasia, no mottling and no detectable vascular differences.

7. None of the three have ever shown any manifestation of eczema, acne or other abnormal skin condition with the exception of the appearance of tiny (usually about .4 mm. diameter) pigmented moles which are not raised. Fred has four such moles on the left side of his face and on his back. John has one on his chest and Henry has one on his left ear and one on his chest.

8. None of the three has a furrowed tongue. The median sulcus of Fred seems a trifle deeper than is the case with Henry and John. All three tongues are similarly shaped and resemble each other closely in the size and distribution of papillae. Teeth of all three are even and regular. At thirty-six months, each had twenty teeth.

9. The likeness of face of the three is so great that even after three years of observation it is frequently impossible for the authors to tell the children apart except by standing the three up in a row and differentiating them by means of the variation in their size.

10. The ear form is alike.

11. There is no discernable difference in hand form. The same is true of nail form.

12. The triplets are closely similar in body build. Fred's neck, however, is inclined to be a bit thicker than the necks of the other two. Fred is also the heaviest of the three. A comparison of their weights and certain of their body dimensions is given in Table I.

13. The mental development of the three as shown by various tests, has been very similar. All three are somewhat retarded in speech development, and John's speech is superior to that of the other two. This superiority is more in the distinctness with which he enuciates than in the number of words he uses or in possession of a greater ability to make his wants known by combining words.

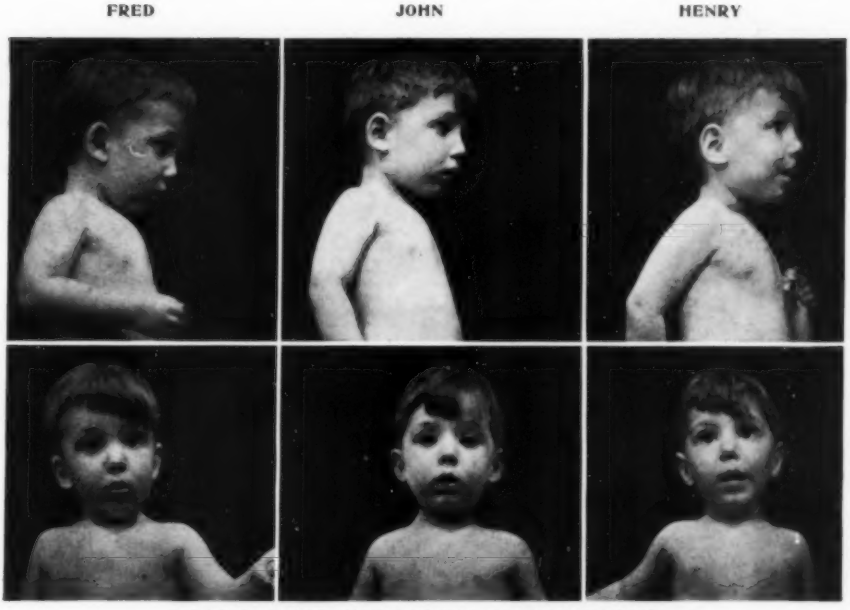
Table II gives the results of the Merrill-Palmer mental scale, Kuhlmann-Binet and the Stanford-Binet scales. An analysis of the test items shows striking similarity in the responses of the three boys. Their scores may be considered as practically identical. The slight differences of one or two months in the respective mental ages and of not more than five points in the respective intelligence quotients may easily be the result of chance or of deficiencies in the tests themselves as measuring instruments for these early years. The performance of the

TABLE. I. Body Measurements at Three Years

	Fred	John	Henry
Weight	15.047 kg.	13.296 kg.	12.850 kg.
Vertex	92.7 cms.	93.0 cms.	91.9 cms.
Stem	55.3 "	55.2 "	54.9 "
Head	51.0 "	49.2 "	49.2 "
Chest	53.0 "	50.5 "	50.0 "
Umbilicus	55.5 "	49.5 "	50.5 "

TABLE II. Scores of Mental Tests

	Fred	John	Henry
Merrill-Palmer Scale		Date: 9-29-31	
Score	23	20	25
Chronological Age	33	33	33
Mental Age	29	28	30
Intelligence Quotient	88	85	91
Kuhlmann-Binet Scale		Date: 12-30-31	
Chronological Age	36	36	36
Mental Age	34	34	32
Intelligence Quotient	94	94	89
Stanford-Binet Scale		Date: 12-17-31	
Chronological Age	36	36	36
Mental Age	34	32	32
Intelligence Quotient	94	89	89



MORE ALIKE THAN THEIR PHOTOGRAPHS

Figure 10

Fred, John, and Henry at the age of about three years have distinctly different "camera faces." Perhaps the photographer neglected to say "smile please" in the same tone of voice for all six poses. There is a difference of six points in I. Q.

triplets on the tests would indicate them to be of average intelligence.

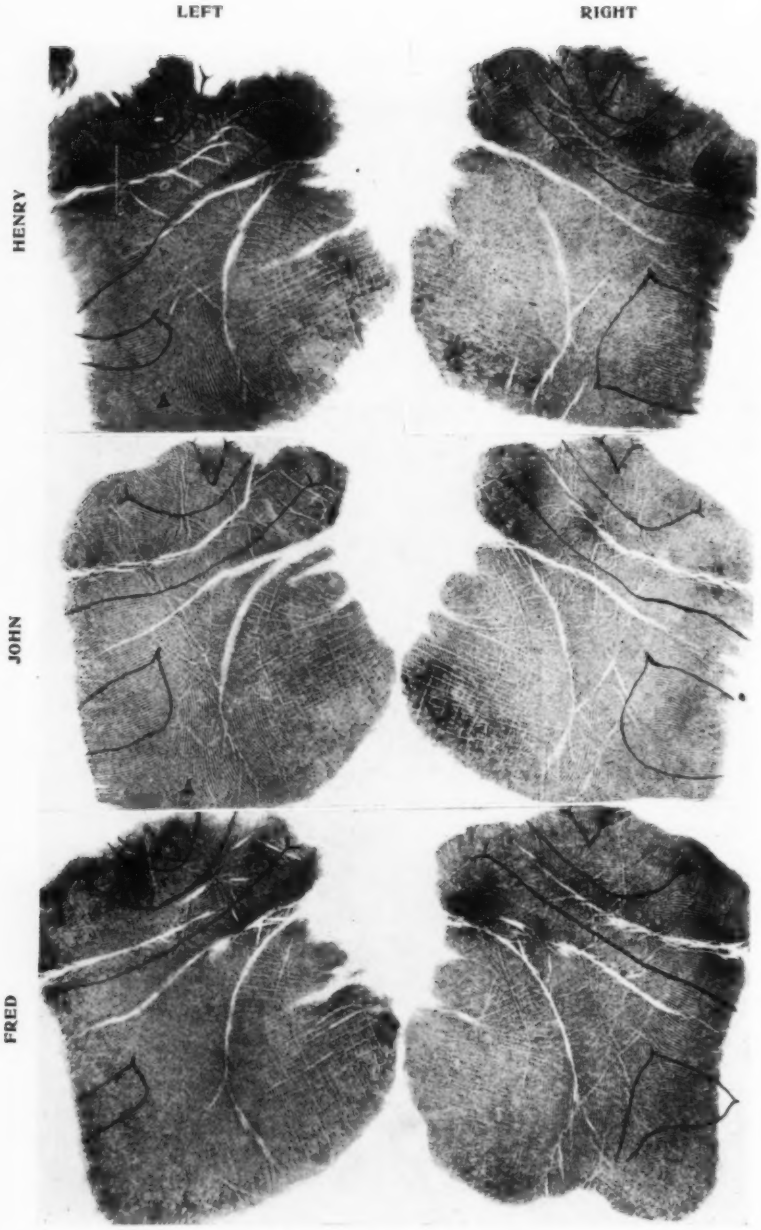
A striking similarity of response is also noted in their performance of the developmental schedule of the Yale Psycho-Clinic. Of thirty-four items, in all but three instances, their respective performances were given the same ratings.

14. All three of the triplets have avoided to date the acute contagious diseases of childhood. All three had a moderately severe case of trench mouth at two years of age, and all three suffered from an internal infection at eighteen months. The diarrhea during the internal infection was moderately severe, but of short duration.

Basal metabolic rate determination, made by means of the apparatus devised by Talbot of Boston, were as follows: Fred, minus 4%; John, minus 8%; Henry, minus 7%. The limit of error of the determination is, of course, far greater than the slight differences shown by these results.

Fred's tendency to use his left hand more frequently than his right was noticed at eighteen months. He used his left hand in transferring food to his mouth, and in later months, in holding a pencil. His mother, in an attempt to cure him of this habit, encouraged him to use his right hand. At present he uses his right hand slightly more than his left, but has a tendency to hold a pencil in his left hand.

15. The formulae of the palm patterns as worked out by Dr. H. H. Newman of the University of Chicago are as follows:



PALM PRINTS OF THE TRIPLETS

Figure 11

The resemblance between the palm prints is striking and is considered by Dr. H. H. Newman to be strong evidence that the twins are monozygotic. In palm characteristics Henry and John are the most alike, but in fingerprint characteristics Fred and John show the closest resemblance.

Left Palm Patterns

Fred	11.7.7.5′—tt″—L^r.O.O.O.L.
John	11.7.7.5′—tt″—L^u/L^r.O.O.O.L.
Henry	11.7.7.1—tt″—L^u.O.O.O.L.

Right Palm Patterns

Fred	11.x.7.5′—t′t″—L^cO.O.O.O.
John	11.x.7.5′—tt″—L^u.O.O.O.O.
Henry	11.x.7.5′—tt″—L^u.O.O.O.O.

The palm prints may be seen in Figure 11.

Dr. Newman's comments on the palm prints follow:

Line *A* of Henry is the only aberrant item in the six hands. The three right hands all have the same abortive line *C* (x), a rare peculiarity. On the whole, Henry and John are a little more alike, but they are all extremely similar and undoubtedly monozygotic.

Dr. Newman's description of the finger prints is as follows:

	Left					Right				
	1	2	3	4	5	1	2	3	4	5
Fred	U	R	U	U	U	U	R	U	U	Wlu
John	U	R	U	U	Wlu	U	R	U	W	Wlu
Henry	U	R	U	W	U	U	R	R	W	U

There are radial loops on all index fingers. There are pocket loops on the right and left little fingers of John and right little finger of Fred. There are whorls on the fourth finger right and left of Henry and on the right fourth finger of John.

The total ridge counts of all fingers are:

	Right	Left	Total
Fred	57	53	110
John	58	53	111
Henry	43	61	104

Fred and John are more alike in all finger print characteristics. Henry is the odd one.

It will be noted that in the matter of downy hair growth John and Henry are most alike, having no hair whorl between the scapulae. They are also most alike in body build and in palm prints. However, in finger prints, Fred and John are more alike.

History of Growth and Nutrition

All three triplets were put on artificial feeding on the fifth day after birth. The preparation used was Mead-Johnson's S.M.A. John and Fred gained well on this mixture, but Henry after a short time began to regurgitate his feedings. Because of this, he gained slowly and at fourteen weeks weighed 2,835 grams compared with 4,337 grams for Fred and 4,082 grams for John. His S.M.A. formula was therefore discontinued and another formula substituted. He tolerated this much better for about a week and then had a recurrence of the regurgitation. During the next twenty weeks, five different formulae were tried, each one apparently successful for a few days but followed by a return of the regurgitation. Henry's condition during the greater part of the six months was such that neither the parents nor the physician expected him to survive. At the end of thirty-three weeks, he weighed 4,309 grams, compared with 6,124 grams for Fred, and 5,897 grams for John. It is interesting to note that from the twenty-fifth week, when their formulae was changed from double strength S.M.A. to barley water and certified milk, until the thirty-third week when it was changed to Dextrolax and certified milk, neither John nor Fred made any weight gain. There was, in fact, a slight loss.

After Henry had reached the age of thirty-three weeks, he stopped regurgitating and began to gain rapidly. At one year he weighed 7.485 kilograms, compared with 8.958 kilograms for John, and 9.611 kilograms for Fred. He had no further nutritional difficulty. At two years Henry weighed 11.34 kilograms, Fred 12.70 kilograms, and John 12.25 kilograms. Approximately this weight ratio has been maintained ever since.

Summary

Material for the proof of the dichorionic uniovular origin of a set of boy triplets now four years old is presented.

A summary of the evidence is as follows:

1. The birth membranes consist of a single placenta and two chorions. There is no evidence of a fusion of two placentae.

2. The hair color and form, eye color, skin color, and downy hair of the body as well as the majority of other physical traits show a striking similarity. The palm and finger prints show marked similarities, the palm

prints bearing a closer resemblance than do the finger prints.

3. The mental characteristics as determined by the Merrill-Palmer, Kuhlmann-Binet, and Stanford-Binet tests are very much alike.

4. A history of growth and nutrition concludes the report.

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Theories of Development

MODERN THEORIES OF DEVELOPMENT, *by* LUDWIG VON BERTALANFFY. Translated and adapted by J. H. Woodger. Pp. 204. Price, $2.75. London: Oxford University Press, 1933.

THIS is a reexamination of the fundamental problems of theoretical biology with especial consideration of the light thrown upon them by the results of modern experimental embryology.

The volume presents a lucid and concise critique of the traditional viewpoints of mechanism and vitalism, both of which the author rejects in favor of an organismic doctrine. The book also affords a brief survey of recent experimental embryology and an account, necessarily suggestive rather than exhaustive, of the theories which have been developed from it, such as the axial gradient theory of Child, the field theories of Gurwitsch and of Weiss, and the organizer concept of Spemann.

A short chapter is devoted to Goldschmidt's physiological theory of inheritance and development. Except for this, the question of what light, if any, genetics has cast upon the problem of development is not specifically treated; however, the geneticist will find the embryological facts presented in the book a valuable frame of reference for the consideration of this topic. Moreover, in the chapter on the Present Day Picture of the Developmental Process, the author touches upon the work of J. H. Woodger who, for the first time, has attempted an analysis by logistic methods of certain fundamental biological problems, such as the relation of embryology to genetics, and the meaning and validity of the biogenetic law. The section on Woodger's studies is primarily an introduction to his method, and does not attempt to summarize his conclusions, but the reader who is induced by it to approach Woodger's papers is likely to find much assistance in clarifying issues upon which both embryologists and geneticists occasionally succumb to muddy thinking.

The present volume is at once a translation and a revised edition of Bertalanffy's *Kritische Theorie der Formbildung*, which appeared in 1928. Less space is given to historical treatment of the controversies of theoretical biology, and somewhat more emphasis is placed upon recent embryological research. Both text and bibliography have been revised to include work published through 1930.

PAUL R. DAVID,
Storrs Agricultural Experiment Station.

Grant to Institute of Forest Genetics

SUPPLEMENTING its grant of $2,100 last spring, the Carnegie Institution of Washington has just made a grant of $2,800 as emergency aid to the Institute of Forest Genetics, located at Placerville, California.

THE INHERITANCE OF A YELLOW-SPOT CHARACTER IN THE BEAN

M. C. PARKER*
University of Wisconsin

CHLOROPHYLL-DEFICIENT types have been reported in many genera of plants. As is to be expected, such deficiencies have been observed most frequently and extensively in species subjected to extensive genetical experimentation. The number of such types so far reported in the common bean, however, is relatively small. The data presented here are based on the results of crosses between normal green and a chlorophyll-deficient type of *Phaseolus vulgaris* L., which is termed "yellow-spot."

Plants exhibiting the defect have definite, circular yellow spots on the primary as well as on the compound leaves. The spots on the leaves of some plants are so numerous that irregular yellow patches are formed. This type has been designated "intense" yellow-spot. Plants on which fewer spots are present and no appreciable coalescing occurs are termed "moderate" yellow-spot. Plants affected with the abnormality appear as vigorous in growth as normal plants. Figure 13*A* is a photograph of a compound leaf of a moderately spotted plant. If compared with the photograph (Figure 13*B*) of an intensely spotted leaf it will be seen to show fewer spots and less tendency for the spots to fuse and form irregular yellow patches. Figure 12*A* is a photograph of a leaf from a normal green plant. A leaf of the original plant from which seed was saved for this study is shown in Figure 12*B*.

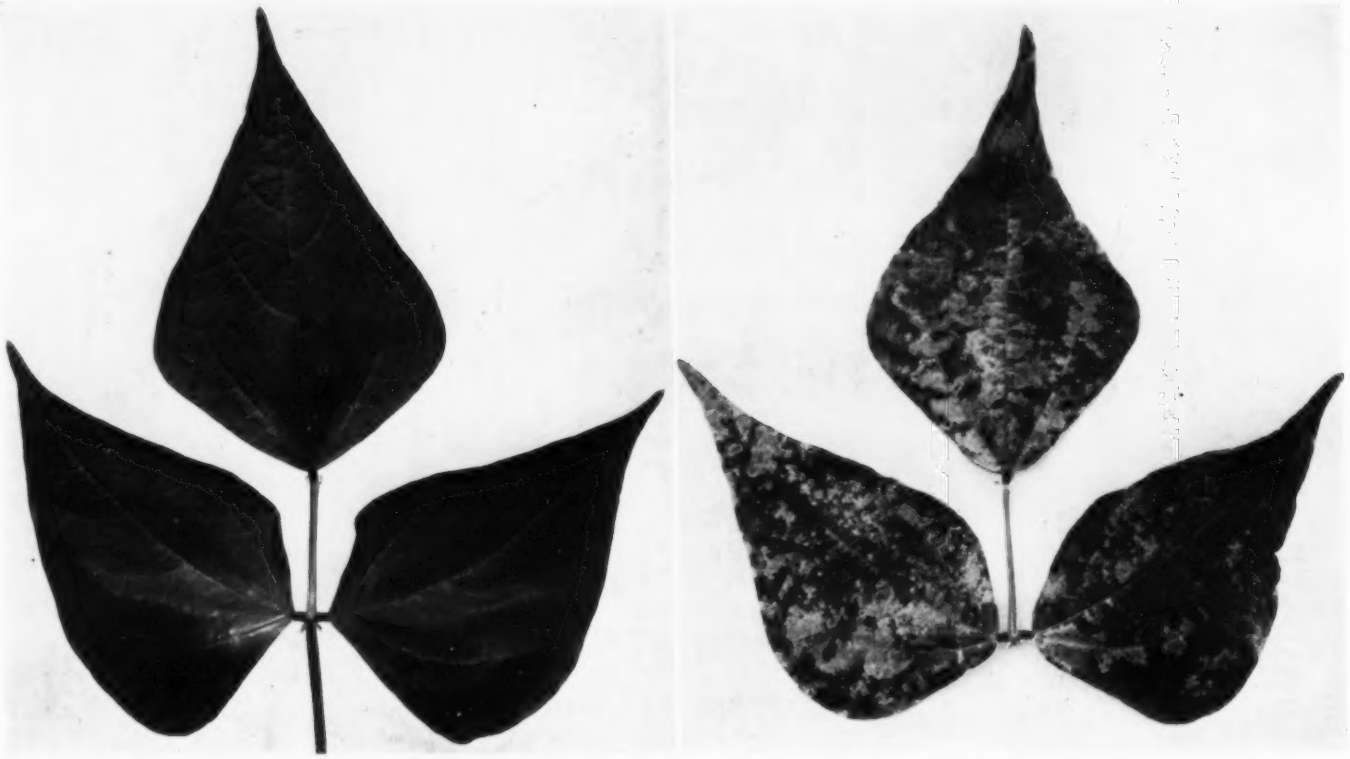
The character was first observed in the U. S. Department of Agriculture bean trials at Greeley, Colorado. It occurred in all the plants of an advanced generation selection from a Stringless Green Refugee × Well's Red Kidney cross. It was later observed in a strain of Well's Red Kidney growing near Moscow, Idaho. Seed of plants from these two sources was kindly supplied by Dr. W. J. Zaumeyer, Bureau of Plant Industry, U. S. Department of Agriculture.

Other Chlorophyll-Deficient Types in the Bean

Burkholder and Muller[2] reported an abnormality in beans which closely resembles the mosaic disease except that it is non-transmissible. The light areas of the mottled leaves are yellowish and the leaves have a tendency to twist and become distorted although they are not as severely affected in this respect as mosaic diseased plants. This pseudo-mosaic, as they termed it, was found in a family derived from a cross between White Marrow and Flat Marrow and occurred in all the plants of the progeny. Crosses between the chlorophyll-deficient type and normal green plants gave a normal F_1 and a ratio of 15:1 in F_2, the defect being recessive. Johannsen[4] reported a case of albinism in beans which he belived to have arisen as a bud mutation. He also described two aurea plants, but gave no observations of the genetics of these forms. Tjebbes and Kooiman[6] used an albino bean plant in grafting experiments. An albino scion grafted onto a green stock developed small patches of green on the leaves and a few narrow stripes on the pods. Seed

*Contribution from the Division of Horticultural Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture in cooperation with the Wisconsin Agricultural Experiment Station. Paper No. 156 from the Department of Genetics. Published with the approval of the Director of the Station.

The writer wishes to express his appreciation for the helpful advice given during the course of this investigation by Dr. R. A. Brink.

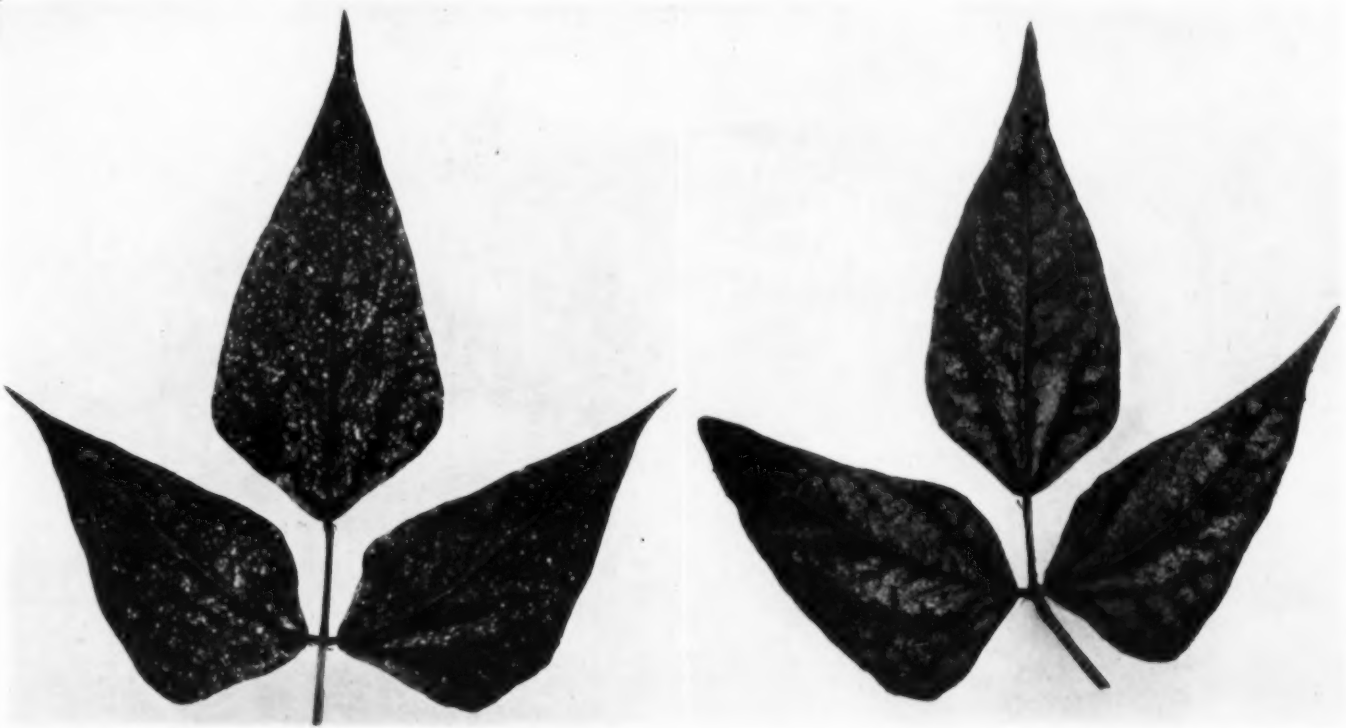


A B

NORMAL AND INTENSELY SPOTTED LEAVES

Figure 12

A—Leaf from a normal green plant in the F_2. Approximately a quarter of the F_2 plants were normal green—such plants bred true for normal green leaves. *B*—Compound leaf in a plant with intense spotting from which the yellow-spotting stock was derived.

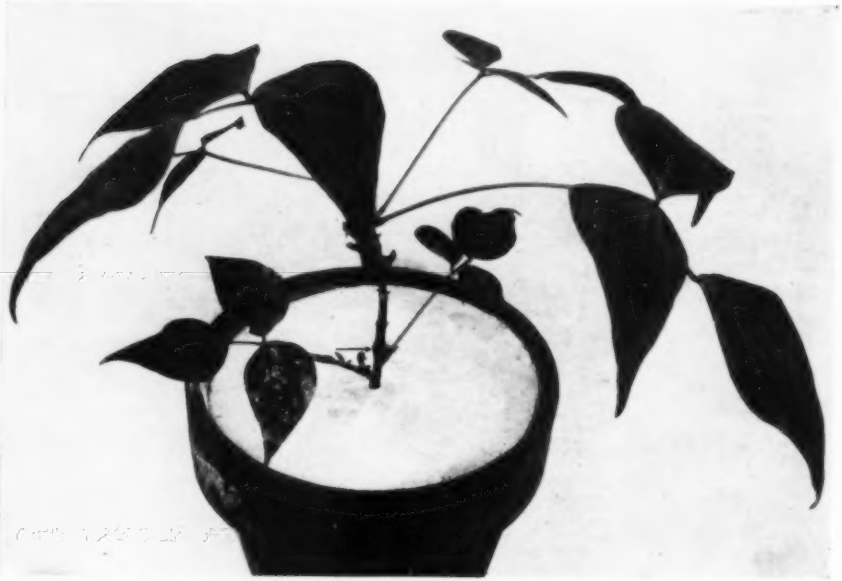


A B

VARIATION IN F_2 SPOTTING

Figure 13

Compound leaves from two F_2 plants showing: *A*—moderate degree of spotting and *B*—intense spotting with coalescing of spots to form irregular yellow patches. The moderately spotted plants have been shown to be heterozygous for the spotting gene while the intensely spotted plants are homozygous.



SPOTTING NOT TRANSMITTED THROUGH SAP

Figure 14

Whip-grafted plant with normal green scion and yellow-spot stock. No spotting is evident in the scion and no apparent inhibition of spotting occurs in foliage of the stock. The arrow indicates the graft union. The occasional light colored flecks in the large trifoliates are due to defects in the photograph and were not shown by the plant.

from these pods produced some variegated plants. No explanation was given for the appearance of small patches of chlorophyll in the apparently albino scion.

Experimental Methods

Reciprocal crosses were made between normal green plants and plants affected with yellow-spot. Michigan Robust and Well's Red Kidney were the varieties used as normal parents. The F_1 hybrids were grown in a cheesecloth covered cage to protect them from mosaic infection as it was desirable to keep the plants healthy in order to classify the material more accurately in respect to the chlorophyll character. The cage also protected the plants from cross-pollination by insects. The seed of each plant was harvested separately and preserved for an F_2 analysis.

Two inoculation methods were used in testing the transmissibility of the character. Leaf tissue from heavily spotted plants was macerated in a mortar and placed in a cheesecloth pad. A little white sand was added as an abrasive agent. The leaves of the plants to be inoculated were then rubbed on the upper surface with the pad of cheesecloth containing the macerated tissue. The second method consisted of placing the ground-up tissue on the leaf to be treated and working the material into the leaf blade by means of a sterile needle.

Transmission Experiments

Attempts at transmitting the character artificially gave negative results. A total of 98 plants from three varieties (27 Michigan Robust, 29 Corbett Refugee, and 42 disease-free

Stringless Green Refugee) were inoculated with macerated leaf tissue from yellow-spot plants by leaf rubbing, and 102 plants (24 Michigan Robust, 29 Corbett Refugee, and 49 disease-free Stringless Green Refugee) were inoculated by the needle puncture method. In no case was the character transmitted by these inoculation methods.

Grafts made with chlorophyll-deficient plants as stocks also gave negative results. The plants were whip-grafted in the epicotyl region just as the first compound leaves were expanding. The graft wound was entirely covered with melted paraffin as described by Leach.[5] Severing of the tops of the plants used as stocks allowed the development of the embryonic buds, located just above the cotyledons, which ordinarily remain latent. After a week or two the stock, as well as the scion, developed foliage leaves. Figure 14 shows a grafted plant with a yellow-spot stock and a normal green scion. The foliage below the graft union exhibits the characteristic spotting, while the leaves developed on the scion after the time of grafting show no evidences of the defect. These studies have been taken as sufficient proof that the abnormality is not caused by an organism (virus), which can be transmitted by infection or by artificial inoculation.

The F_1 Generation

All F_1 plants from the cross yellow-spot $\times$ normal green and reciprocal were moderately yellow-spotted. When Michigan Robust was used as the normal green parent the hybrid plants exhibited the defect but only in the upper leaves, while plants of the cross Well's Red Kidney $\times$ yellow-spot and reciprocal exhibited moderate spotting in all leaves. These results indicate that the defect is dominant to normal green in inheritance.

The F_2 Generation

From nine F_2 families 755 plants were grown in the greenhouse and classified according to the amount of yellow-spotting. The results are presented in Table I. If these plants are grouped into two classes, deficient and non-deficient, or yellow-spot and normal green, the results closely approximate a 3:1 ratio (obs. 564:191, calc. 566.25:188.75) with the deficient type dominant. If, however, the plants are classified as in the table, dividing the yellow-spot class into "intense" and "moderate" classes, a ratio of 1:2:1 is obtained. Classified in this manner the moderately spotted individuals represent the heterozygous class. This can only be substantiated by studying the F_3 generation. Normal green plants, moderately spotted, and intensely spotted F_2 plants were selfed in order to clarify this point. Normal green and intensely spotted individuals are expected to breed true and the moderately spotted individuals should give a 1:2:1 ratio in F_3.

The F_3 Generation

All F_3 individuals derived from plants normal green in F_2 were normal green. From four F_2 individuals 61

TABLE I.—F_2 Generation of Yellow-Spot $\times$ Normal Green and Reciprocal.

Cross	Family No.	Total Plants	Normal Green	Moderate Spotted	Intense Spotted
Y.-S. X Mich. Rob.	205-1	179	45	89	45
" X " "	205-2	181	51	88	42
Y.-S. X W. Red Kid.	206-1	10	4	3	3
W. Red Kid. X Y.-S.	207-1	114	27	58	29
" " X "	207-2	52	14	23	15
" " " X "	208-1	93	20	52	21
" " " X "	206-2	88	22	43	23
" " " X "	208-3	14	3	8	3
" " " X "	206-4	16	5	7	4
Observed Totals		755	191	377	187
Calculated on 1:2:1 Basis			188.75	377.50	188.75
Deviation Obs. from Calc.			+2.25	-.50	-1.75

TABLE II.—F_3 Generation of Yellow-Spot $\times$ Normal Green Derived from Plants Moderately Yellow-Spotted in F_2.

Family No.	Number of Plants			
	Total	Green	Moderate Yellow-Spot	Intense Yellow-Spot
207-1-1	13	3	7	3
207-1-2	20	5	10	5
207-1-3	16	5	6	5
207-1-4	15	4	8	3
207-1-5	20	5	10	5
207-1-8	8	2	3	3
207-1-10	12	3	6	3
208-4-2	13	3	8	3
Totals	119	29	60	30

F_3 plants were grown all of which were normal green. Intensely spotted F_2 plants also bred true. From five intensely spotted F_2 individuals 70 F_3 plants were grown. They were all intensely spotted. Plants moderately spotted in F_2 gave a 1:2:1 ratio as expected. The F_3 results derived from plants moderately yellow spotted in F_2 are presented in Table II. A total of 119 plants from 8 families were grown: 30 were intensely yellow spotted, 60 were moderately yellow spotted, and 29 were normal green. These results indicate that the moderately spotted plants represent the heterozygous class. Intensely spotted plants, and normal green plants represent the homozygous dominant, and homozygous recessive classes, respectively.

Discussion

The results of crossing yellow-spot plants and normal green plants indicate that this character is governed by one Mendelian factor behaving as a simple dominant. If the chlorophyll-deficient class, however, is separated on the basis of the relative degree of spotting another explanation of the results is possible. When the yellow-spotted class is separated into moderate and intense spotting, as shown in Table I, a ratio of 1 normal green, to 2 moderately spotted, to 1 intensely spotted plant is obtained. These results can be interpreted by assuming that the factor for yellow-spot is incompletely dominant to the factor for normal green foliage. Consequently the F_1 plants are moderately spotted, and in F_2 a 1:2:1 ratio is obtained. This assumption is substantiated by the results obtained in the F_3 generation. The intensely spotted plants under this interpretation are the homozygous dominant plants. This can be represented by designating the factor for yellow-spot as Y and the factor for normal green as y. Then YY plants are intensely spotted, Yy plants are moderately spotted, and yy individuals have normal green foliage. The heterozygous class more closely resembles the homozygous deficient type. The yellow-spot character, therefore, should probably be considered as incompletely dominant to normal green. Whether yellow-spot, or normal green is incompletely dominant, however, is unimportant.

Summary

1. Results of crossing a chlorophyll-deficient type of bean plant, termed "yellow-spot," with normal green plants are presented.

2. The F_1 plants were moderately spotted, and a ratio of one normal green, to two moderately spotted, to one intensely spotted plant was obtained in the F_2 generation.

3. The intensely spotted (YY) and the normal green (yy) plants bred true in the F_3 generation. The moderately spotted (Yy) plants gave a 1:2:1 ratio as obtained in F_2.

4. Attempts to transmit the character by leaf rubbing, and by needle puncture methods of inoculation were unsuccessful.

5. The character was not transmitted by grafting.

6. Yellow-spot may be considered either as a simple Mendelian dominant, or as incompletely dominant to normal green.

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Index to Volume XXIV

OF THE

Journal of Heredity, 1933

A

Abnormal "Abnormal Psychology," 119.
Absence of Tooth Enamel, Frank H. Clark and Cecile S. Clark, 425.
Afrikander Cattle, 449.
Agropyrum, 329.
Albinism in Wheat, 159; in Fowl, 379.
Allelomorphism of Silver and Siamese Coat Variations in the Cat, Clyde E. Keeler and Virginia Cobb, 181.
Allen, Edgar, Sex and Internal Secretions, 249, 434.
Allyn, Robert Starr, Plant Patent Queries, 55.
The Anatomy of Development, 282.
Animal Breeding and Genetics:
- Afrikander Cattle, 449.
- Albinism in Fowl, 379.
- Artificial Insemination, 87.
- "Buffalo" (Cretin) Calf, 319.
- Cattle Statistics, 158.
- Coat Color in Horses, 65; in Cat, 181; in Cattle, 283, 347.
- Color Genes in the Fowl, 301.
- Eyeless Pigs, 105.
- Fish Genetics, 317.
- Foot Length in Mouse, 440.
- Frizzling Modifier in Fowl, 153.
- Furless Rabbits, 81.
- History of Rambouillet Sheep, 19.
- Hound-Eared Mice, 157.
- Inbreeding Horses, 185; Poultry, 93; Swine, 199.
- Livestock Scaling Instrument, 107.
- Mallard Ducks, 467.
- Retarded Feathering in the Fowl, 431.
- Rexing the Lilac Rabbit, 35.
- Rumpless Gene in Fowl, 293.
- Semi-Featherless Poultry, 101.
- Sex Linkage in Ducks, 18.
- Sex Determination, 265.
- Skin Tumors in Swine, 361.
- Spurlessness of the White Leghorn, 71.
- Superfetation in the Waltzing Mouse, 111.
- Terrapin Hybrids, 231.
- Twins in Cattle, 229.
- Two-Faced Kitten, 103.
- What is a Gene?, 369.
- White Star in Deer Mouse, 245.

Anthropometry of the American Negro, 113.
Apple, A "Reverse" Mutation in, 48.
Applied Cytology for the Plant Breeder, 115.
Artificial Culture of Sweet Cherry Embryos, H. B. Tukey, 7.
Artificial Insemination, 87.
Autotetraploids, 320.

B

Babcock, E. B., John Belling, 297.
Baker, Mary Francis, A "Strangling" Eucalyptus, 403.
Barnard Trustees on Motherhood, 207.
Barto, Elizabeth, and R. R. Huestis, Inheritance of a White Star in the Deer Mouse, 245.
Bavink, Bernhard, Eugenik und Weltanschaung, 262.
Bean, Yellow-Spot in, 481.
Bean, R. B., The Races of Man, 335.
Becker, R. B., Recessive Coloration in Dutch Belted Cattle, 283.
Belgians, (horses), 185.
Belling, John, 297.
Benton, R., The Mechanistic Autonomy of Nature, (Rev.), 205.
Berry, Scott, Special Education, 46.
Bertolet Family, Twinning in, 139.
Bissonnette, Thomas Hume, A Two-Faced Kitten, 103.
Blackberry Crosses, Pseudogamy in, 313.
Blood sugar, 354.

Books Received and Books Reviewed:
- Anthropometry of the Negro, 113.
- The Ape and the Child, 239.
- Applied Eugenics, 435.
- The "Beagle" Diary, 435.
- Behind the Door of Delusion, 120.
- Beitrage zu einer Genotypischen Analyse, 137.
- Born That Way, 436.
- The Bulpington of Bulp, 323.
- Cancer and Race, 206.
- Cattle Farming in South Africa, 238.
- The Changing Culture of an Indian Tribe, 34, 203.
- China Today: Economic, 184.
- Chromosomes and Plant Breeding, 115.
- Contemporary Social Problems, 34.
- Crimes and Criminals, 238.
- Differential Fertility, 239.
- Einfuehrung in die Menschliche Erblichkeitslehre und Eugenik, 112.
- Endocrine Medicine, 179.
- Energy and Matter, 70.
- Erbbiologischer und Eugenischer Wegweiser fur Jedermann, 70, 184.
- The Eugenic Predicament, 463.
- Eugenik und Weltanschauung, 70, 262.
- Experimental Analysis of Development, 348.
- The Family, 323.
- The First Two Years, 238.
- Florida Wild Life, 34.
- Foundations of Abnormal Psychology, 119.

Genetics of Sheep, 323.
Growth of Child, 70, 118, 323.
Grundlagen, Wege und Ziele der Okologischen Haustiergeographie, 34, 197.
Grundzuge einer Allgemeinen Biologie, 248.
Grundzuge Konsititutions-Anatomie, 282.
Heredity and the Social Group, 436.
The Heroic Age of Science, 239.
Human Aspects of Unemployment, 323.
Human Sterilization, 244.
L'Immigrazione Degli Ebrei, 70, 138.
In Place of Profit, 238.
Intellectual Crime, 239.
Introduction to the History of Science, 383.
Jocasta's Crime, 435.
Korperform und Leistung Sechzehnjahriger Lehrlinger und Mittelschuler von Zurich, 70.
Kuhn-Archiv, 436.
Le Leggi di Mendel, 251.
Life in the Making, 435.
The Life of Mendel, 123.
Limitations of Science,
The Long Road from Savagery to Civilization, 436.
Man into Woman, 436.
The Mechanism of Creative Evolution, 39.
The Mechanistic Autonomy of Nature, 205.
Das Menschliche Auge, 435.
Morphologische Untersuchungen an der Fibula des Menschen, 70.
Multiple Sklerose, 307.
Nut Growing, 356.
L'Oeuf Humain et ses Annexes, 321.
Order of Birth, Parent-Age and Intelligence, 193.
Our Children, 34.
Parents and Sex Education, 34.
Das Personliche Tempo, 315.
The Plant World in Florida, 238.
Plants, What They Are, and What They Do, 338.
Population Trends in the U. S. 238, 404.
Popolaziani Africane, 70, 124.
Poultry Breeding, 198.
Preparation for Marriage, 239.
Principles of Genetics, 117.
Proceedings of Genetics Congress, 69, 436.
The Promise of Youth, 417.
Psychologische Untersuchungen, 434.
The Races of Man, 70, 335.
Recent Advances in Agricultural Plant Breeding, 286.
Recent Advances in Plant Genetics, 320.
Rural Social Trends, 238.
Science and Civilization, 323.
Science of Reproduction, 239.
Scientific Theory and Religion, 238. 434.
Sex and Internal Secretions, 70, 249, 434.
Sex Determination, 239.
Sex in the Plant World, 436.
The Smallest Living Things, 71, 390.
Some Recent Researches in the Theory of Statistics, 364.
The Sorcerers of Dobu, 34.
So This is Science!, 238.
Space, Time, and Relativity, 70.
Special Education, 46.
A Study of a Community, 435.
The Technique of Social Progress, 214.
Textbook of General Biology, 238.
What We Are and Why, 436.
Will It Be a Boy?, 194.
Zwillingsforchung Beim Rind, 229.
Zwillingstuberkulose, 323.
Bovine Vital Statistics, 158.
Brandt, Walter, Grundzuge einer Konstitutions-Anatomie, 282.
Bricks Without Straw, 463.
Brink, R. A., Heritable Characters in Maize—XLVI, 325.
Broad Bean Genetics, 137.
Bryngelson, Bryng, and Thomas B. Clark, Left-Handedness and Stuttering, 387.
Bud mutations, 48.
Bud Pollination in Cabbage and Radish, Y. Kakizaki and T. Kasai, 359.
Bud Variations in the Agen Prune, Shamel, Pomeroy, Caryl, and Harmon, 289.
A "Buffalo" Calf, L. J. Horlacher, 319.
"Butterjaps," 357.

C

Calkins, Gary N., The Smallest Living Things, 390.
Campbell, C. G., The Present Position of Eugenics, 144.
Cancer, 206, 310, 361.
A Case of Superfetation in the Waltzing Mouse, Wm. H. Gates, 111.
Castle, W. E., Hurst's Mechanism of Creative Evolution, (Rev.), 39; The Furless Rabbit, 81.
Cat, Silver, 181; two-headed, 103.
Cataract, 316.
Cattle, 158, 283, 347.
Chilling, 165, 169.
China's Economics, 184.
Chinchilla rabbit, 181.
A Chlorophyll Mutation in Wheat, K. W. Neatby, 159.
Chromosome Behavior in a Triploid Tradescantia, Edward King, 253.
Chromosome Photographs, 298.
Chromosomes of the Potato, 86.
Clark, Frank H., and Cecile S. Clark, Absence of Tooth Enamel, 425.
Clark, Thomas B., and Bryng Bryngelson, Left-Handedness and Stuttering, 387.
Clarke, Alfred E., Recent Advances in Plant Genetics, (Rev.), 320.
Claw Fingers, 241.
Coat Color in Fowl, 301. 379; in Cattle, 347; 283; in Cat, 181.
Cobb, Virginia, and Clyde E. Keeler, Allelomorphism of Silver and Siamese

Coat Variations in the Cat, 181.
Cole, L. J., and Ivar Johansson, Sex Control Again, 265.
Color-genes in the Fowl, 301; in Mouse, 245; in Cattle, 379.
Commissioner of Patents Replies, 163.
Congenital Melanotic Cutaneous Tumors in Swine, J. E. Nordby, 361.
Control of Sex, 265.
Cook, Robert: Other Plant Patents, 49; Chromosomes of the Potato, 86; Heredity and Mental Hygiene, 121; Reply to Eldon Moore, 126; Reply to Commissioner of Patents, 163; Other Pedigrees of Syndactyly and "Lobster Claw," 243; Mongolian Twins, 281; Von Recklinghausen's Disease, 309; Thomsen's Disease, 345; Science Through the Centuries (Rev.), 383.
Couch Grass-Wheat Hybrid, 329.
Crest and Rumplessness, 293.
Crew, F. A. E., Sex and Internal Secretions, (Rev.), 249, 434.
Curtius, Friedrich, Multiple Sklerose, 307.
Cytology, 115, 417.

D

Danforth, C. H., The Reaction of Dominant White with Yellow and Black in the Fowl, 301; L'Oeuf Humain et ses Annexes, (Rev.), 321.
Darlington, C. D., Chromosomes and Plant Breeding, 115.
Darrow, Geo. M., Chromosomes and Plant Breeding, (Rev.), 115.
Darrow, M., and G. F. Waldo, Pseudogamy in Blackberry Crosses, 313.
Darrow, George M., et al, Twelve Years of Strawberry Breeding, 391.
Davenport, Charles B., Swiss Body Measurements, 192.
David, P. R., Principles of Genetics (Rev.), 117; Behind the Door of Delusion, (Rev.), 120; Beitrage zu einer Genetypischen Analyse der Ackerbohne, Rev.), 137; Grundlagen, Wege und Ziele der Okologischen Haustier-Geographie, (Rev.), 197; Eugenik und Weltanschaung, (Rev.), 262; Multiple Sklerose und Erbanlage, (Rev.), 307; Experimental Analysis of Development, (Rev.), 348; Modern Theories of Development, 480; Twin Psychology, (Rev.), 434.
Deafness as a Eugenical Problem, W. J. Tinkle, 13.
Deer Mouse, 245.
Demerec, M., What Is a Gene?, 369.
Dental Defects Inherited, 425.
Descent and Origin of the Afrikander Cattle, H. Epstein, 449.
Determination of Sex, 265.
Determining Similarity of Triplets and Quadruplets, S. E. T. Lund, 195.
Detwiler, Samuel B., Twinning in Seven Generations of the Bertolet Family, 139.
Diabetes, 349.
Diagnosing Identical Twins, 339, 407, 429, 443.
Dickinson, W. F., and J. L. Lush, Inbreeding and Genetic History of the Rambouillet Sheep in America, 19.
The Disintegration of a Primitive Culture, 203.
Doisy, E. A., Priority in Isolation of the Follicular Hormone, 434.
Dominance Modifiers (Fisher), 156.
Ducks, Pattern-genes in, 467.
Dunn, L. C., The Life of Mendel, (Rev.), 123; Poultry Breeding, (Rev.), 198.
Dunn, L. C., and Edmund W. Sinnott, Principles of Genetics, (Rev.), 117.
Durken, Bernhard, Experimental Analysis of Development, 348.
Durre, Konrad, Erbbiologischer und Eugenischer Wegweiser, 184.
Dwarf Mutation in Kafir, J. B. Sieglinger, 337.

E

Ear Variation in Mice, 157.
Earliness and Seasonal Growth Habit in Wheat, H. H. McKinney and W. J. Sando, 169.
"Ectogenesis" of Cherries, 7.
Education and Size of Family, N. L. Whetten, 275.
"Elephantiasis," 309.
Embryo-culture of Sweet Cherries, 7.
Embryology and Genetics, 348.
Enamel, Absence of on teeth, 425.
Endocrines, 249, 174, 305.
Engelbach, W., Endocrine Medicine, 179.
Enriques, Paolo, Le Leggi Mendel e i Cromosomi, 251.
Epistatic color-genes in the fowl, 301.
Epstein, H., Descent and Origin of the Afrikander Cattle, 449.
Eucalyptus, Teratology in, 403.
Eugenic Predicament, The, J. H. Kempton (Rev.), 463.
Eugenic Sterilization, 120, 142, 230.
Eugenics, see also *Human Heredity*.
Eye-color of twins, 407.
Eye Disease, Hereditary, 316.
Eyeless Pigs, 105.

F

Family, Education and Size of, 275.
Fifth World Poultry Congress, 92.
Finger-patterns and Eye-color, 407, 429.
Fischer on Race Crossing, 239.
Fish Hybrids and Fish Genetics, Myron Gordon, 317.
Fisher, dominance modifiers, 156.
Follicular Hormone, 434.
Forbes, A. W., Is Eugenics Dead? 143.
Fowl: Spurlessness, 71; Inbreeding and Intercrossing, 93; A Gene Modifying Frizzling, 153; Reaction of Dominant White with Yellow and

Black, 301; Albinism, 379; Retarded Feathering, 431; Linkage, 293.
Fraser, Allan C., Heritable Characters of Maize, XLIV, 41.
Frisheisen-Kohler, Ida, Das Personliche Tempo, 315.
Frizzled Plumage, 293.
Frizzling in the Fowl, 153.
The Furless Rabbit, W. E. Castle, 81.
Fused Fingers, 240.

G

Gates, R. Ruggles, The Changing Culture of an Indian Tribe, (Rev.), 203; The Races of Man, (Rev.), 335.
Gates, Wm. H., A Case of Superfetation in the Waltzing Mouse, 111.
Gene, 369.
Gene Modifying Frizzling in the Fowl, Walter Landauer, 153.
Gene-Mutations in the Tomato, 129.
Gene Photograph, 299.
Genetic Studies of Monozygotic Twins, D. Cecil Rife, 339, 407, 443, 429.
A Genetic Picture-Book,—and More, 39.
Genetics, See also, *Plant Breeding, Animal Breeding, Human Heredity.*
Genetics and Embryology, 348.
Genetics in Cat, 181.
Genetics of Multiple Sclerosis, 307.
Genius, a Review, A. Weinstein, 417.
Genus Hybrid, 329.
Glands, 179, 249.
Glossary of Genetic Terms, See back covers of the Journal.
Glycosuria, 349.
Good, C. G., Horse Breeding Methods, 185.
Gordon, Myron, Fish Hybrids and Fish Genetics, 317.
Grant to Institute of Forest Genetics, 480.
Green, C. V., Inheritance of Foot Length, 440.

H

Hair Whorl, 443.
Hale, F., Pigs Born Without Eye Balls, 105.
Hance, Robert T., Will It Be a Boy?, (Rev.), 194.
Hart, Hornell, The Technique of Social Progress, 214.
Hayes, H. K., Recent Advances in Plant Breeding, 286.
Hearn on the "Network of Descent," 151.
Hereditary Eye Diseases, 316.
Hereditary Radium-Induced Variations in the Tomato, E. W. Lindstrom, 129.
Heritable Characters in Maize: Silky Ears, Allan C. Fraser, 41; Nana, H. W. Li, 279; Liguleless-2, R. A. Brink, 325.
Herskovits, Melville J., Anthropometry of the American Negro, 113.
Hildebrand, Samuel F., Hybridizing Diamond-Back Terrapins, 231.
Holmes, S. J., Growth and Development of the Child. (Rev.), 118; Social Progress in Review, 214; Eugenic Predicament, 463.
Horlacher, L. J., A "Buffalo" Calf, 319.
Hormones (sex), 250.
Horse Breeding, 185.
Hound-Eared Mice, B. W. McPheters and C. C. Little, 157.
Huestis, R. R., Anthropometry of the American Negro, (Rev.), 113.
Huestis, R. R., and Elizabeth Barto, Inheritance of a White Star in the Deer Mouse, 245.
Hughes, E. H., Inbreeding Berkshire Swine, 199.
Hugo de Vries at Eighty-five, G. H. Shull, 3.
Human Genetics in the Medical Curriculum, 405.

Human Heredity and Eugenics:

Abnormal Psychology, 119.
Absence of Tooth Enamel, 425.
Black and White in Africa, 124.
Diagnosing Identical Twins, 339, 407, 443.
Differences in Triplets and Quadruplets, 195.
Education and Size of Family, 275.
Endocrinology and Eugenics, 179.
Eugenic Sterilization, 120, 142, 230, 244.
Eugenics and Race Progress, 64.
Eye Disease, 316.
Follicular Hormone, 425.
Genetics in Medical Curriculum, 405.
Genetics of Deafness, 13.
Genius, 417.
How We Grow, 118.
The Human Ovum, 321.
Identical Twins Reared Apart, 209.
Inheritance of Diabetes, 349.
Inheritance of Twinning, 322.
Is Eugenics Dead?, 143.
Jewish and Gentile Cancer, 206.
Left-Handedness and Stuttering, 387.
Measuring the American Negro, 113.
Mental Hygiene, 121.
Mongolian Twins, 281.
Monozygotic Triplets, 473.
Multiple Sclerosis, 307.
Order of Birth and Intelligence, 193.
Psychic Factors in Development, 248.
Race Crossing, 239.
The Races of Man, 335.
Sex Control, 265.
Sex-Determination Explained, 194.
Sex and Internal Secretions, 249.
Sickle-Celled Anemia, 106.
Swiss Body Measurements, 192.
Syndactylism, 241, 243.
Thomsen's Disease, 345.
Twins in the Bertolet Family, 139.
Von Recklinghausen's Disease, 309.
World Eugenics, 262.

Human Ovum, 321.
Hunt, H. R., "Interest [in Eugenics] Increasing," 150.
Hunter, H., Recent Advances in Agricultural Plant Breeding, 286.
Hurst, C. C., The Mechanism of Creative Evolution, 39.
Hybrid Corn Varieties, 64.
Hybrids, Race, 239.

Hybridizing Diamond-Back Terrapins, S. F. Hildebrand, 231.
Hybrids between Wheat and Couch Grass, S. Verushkine and A. Shechurdine, 329.
Hyperglycemia (Hypoglycemia), 349.

I

"Iarovization," 165, 169.
Idiocy, 281.
Iltis, Hugo, Life of Mendel, 123.
Inbreeding and Intercrossing in Poultry, M. A. Jull, 93.
Inbreeding and the Genetic History of Rambouillet Sheep in America, W. F. Dickinson and J. L. Lush, 19.
Inbreeding Berkshire Swine, E. H. Hughes, 199.
Inbreeding Horses, 185.
Inheritance of Albinism in the Domestic Fowl, D. C. Warren, 379.
Inheritance of Foot Length, C. V. Green, 440.
Inheritance of Waxy Endosperm in Sorghum, R. E. Karper, 257.
Inheritance of White Star in the Deer Mouse, Elizabeth Barto and R. R. Huestis, 245.
Inheritance of a Yellow-Spot Character in the Bean, M. C. Parker, 481.
Inherited Anomalies of Metabolism, M. T. Macklin, 349.
Insemination, 87.
Is Eugenics Dead?, A. W. Forbes, 143.

J

Jaap, R. G., Light-Phase Mallard Ducks, 467.
Jewish and Gentile Cancer, 206.
Johansson, Ivar, and L. J. Cole, Sex Control Again, 265.
John Belling, E. B. Babcock, 297.
Jull, Morley A., Inbreeding and Intercrossing in Poultry, 93; Poultry Breeding, 198.

K

Kakizaki, Yoiti, and Tadayuki Kasai, Bud Pollination in Cabbage and Radish, 359.
Karper, R. E., Inheritance of Waxy Endosperm in Sorghum, 257.
Kasai, Tadayuki, and Yoiti Kakizaki, Bud Pollination in Cabbage and Radish, 359.
Kaysenbrecht, Richard, Rural Sociology: A Challenge of the Times, 40.
Kaznelson, Reuben, L'Immigrazione degli Ebrei in Palestina nei Tempi Moderni, 138.
Keeler, Clyde E., and Virginia Cobb, Allelomorphism of Silver and Siamese Coat Variations in the Domestic Cat, 181.
Kelley, R. B., A Livestock Scaling Instrument, 107.
Kempton, J. H., The Twins of the Father. 322; The Eugenic Predicament (Rev.), 463.
King, Edward, Chromosome Behavior in a Triploid Tradescantia, 253.
Klaus Foundation for Heredity, 192.
Klemola, V., The "Pied" and "Splashed White" Patterns in Horses and Ponies, 65.
Klippart on "Iarovisation," 169.
Kofoid, Charles A., The Smallest Living Things (Rev.), 390.
Kohn, Walter, Psychologische untersuchungen an Zwillingen, 434.
Kozelka, A. W., Spurlessness of the White Leghorn, 71.
Krafft, C. F., Springs of Life, 125; The Mechanistic Autonomy of Nature, 205.
Kronacher, C., Zwillingsforschung beim Rind, 229.

L

Landauer, Walter, Russian Methods of Artificial Insemination Multiply Sires' Value, 87; A Gene Modifying Frizzling in the Fowl, 153; Grundzuge einer Allgemeinen Biologie, (Rev.), 248; Linkage Tests in Poultry, 293; Das Personliche Tempo, (Rev.), 315; Biologie des Radiums, (Rev.), 442.
Landman, J. H., Human Sterilization, 244.
Left-Handedness and Stuttering, B. Bryngelson and T. B. Clark, 387.
Legal Aspects of Sterilization, 244.
Leghorn, Spurlessness of the White, 71.
Legislation in Panama, 429.
Letters to the Editor, 125.
Lewis, N. D. C., Foundations of Experimental Psychology, (Rev.), 119.
Li, H. W., Heritable Characters in Maize, 279.
Light-Phase Mallard Ducks, R. G. Jaap, 467.
Liguleless-2, 325.
Lindstrom, E. W., Hereditary Radium-Induced Variations in the Tomato, 129.
A Linebreeding Program for Horse Breeding, P. B. Pearson and J. L. Lush, 185.
Linkage Tests in Poultry, W. Landauer, 293.
Little, C. C., "Not Dead But Sleeping," 149; Cancer and Race (Rev.), 206.
Little, C. C., and B. W. McPheters, Hound-Eared Mice, 157.
A Livestock Scaling Instrument, R. B. Kelley, 107.
Lobster Claw, 241.
Lucien, Maurice, and Henri Vermelin, L'Oeuf Humain et ses Annexes, 321.
Lund, S. E. Torsten, Determining Similarity of Triplets and Quadruplets, 195.
Lush, J. L., and W. F. Dickinson, Inbreeding and the Genetic History of the Rambouillet Sheep in America, 19.
Lush, Jay L., and P. B. Pearson, A Line-

breeding Program for Horse Breeding, 185.
Lysenko, T. D., originator of iarovization, 166.

M

McKinney, H. H., and W. J. Sando, Russian Methods for Accelerating Sexual Reproduction in Wheat, 165; Earliness and Seasonal Growth Habit in Wheat, 169.
McPheters, B. W., and C. C. Little, Hound-Eared Mice, 157.
Macklin, Madge T., Inherited Anomalies of Metabolism, 349.
Maize, Heritable Characters of, 41, 279, 325.
Mallard Ducks, Sex Linkage in, 18.
Marsh Seedless Grapefruit, 437.
Mead, Margaret, The Changing Culture of an Indian Tribe, 203.
Measuring the American Negro, 113.
Mendel, The Life of, 123.
Mendel, Rediscovery by Hugo de Vries, 3.
Mendelian Ratios, Probability Tables, 78.
Mendelism and Chromosomes, 251.
Mental and Physical Traits of Identical Twins Reared Apart, H. H. Newman, 209.
Mental Disease, 119, 121.
Merino Sheep, History of, 19.
Metabolism, Inherited Anomalies of, 349.
"Metronome" Genes, 315.
Mexico, Eugenic Sterilization in, 230.
Mice, Hound-Eared, 157; Blood Sugar in, 354.
"Mongolian" Twins, 281.
Moore, Elden, Shoulderblades — "Stigma" or "Index"—?, 125.
Morgan, T. H., awarded Nobel Prize, 416.
Morris, R. T., Stigmata of Degeneracy, 126.
Morris, Robert T., Nut Growing, 356.
Moss, Fred A., Foundations of Abnormal Psychology, 119.
Motherhood and Careers, 207.
Mouse, Superfetation in, 111; Inheritance of a White Star in, 245; Inheritance of Footlength, 440.
Multiple Sclerosis, 307.
Mutations, Radium Induced, 129.
Myers, C. E., A "Reverse" Mutation in the Apple, 48.
Myers, C. H., China's Economics, (Rev.), 184.
Myotonia, Inherited, 346.

N

Naked Rabbit, 81.
Nana, Maize, 279.
Neatby, K. W., A Chlorophyll Mutation in Wheat, 159.
Negro, Measuring the American, 113.
Nelson, V. L., and L. W. Sontag, A Study of Identical Triplets, 473.
"Nervous Goats," 345.
Newman, H. H., Mental and Physical Traits of Identical Twins Reared Apart, 209; Zwillingsforschung beim Rind, (Rev.), 229.
Nordby, Julius E., Congenital Melanotic Skin Tumors in Swine, 361.
Nose-Prints of Cattle Twins, 230.
Nuts and Men, (Rev.), 356.

O

Occupation and Family Size, 277.
Oekland, Fridtjof, Will It Be a Boy?, 194.
Oenothera, 4.
Order of Birth and Intelligence, 193.
The Origin of the Marsh Seedless Grapefruit, T. Ralph Robinson, 437.
Other Pedigrees of Syndactyly and "Lobster Claw," R. C. Cook, 243.
Other Plant Patents, Robert Cook, 49.
Otosclerosis, 17.
Ovum, the Human, 321.

P

Paralysis, 345.
Parker, M. C., Inheritance of a Yellow-Spot Character in the Bean, 481.
Parkhurst, Raymond T., and W. King Wilson, Rexing the Lilac Rabbit, 35.
Patents, see *Plant*.
Pearson, P. B., and Jay L. Lush, A Line-breeding Program for Horse Breeding, 185.
Perkins, H. F., "Make Haste Slowly," 148.
Peromyscus, 245.
Photoperiodism, 169.
"Pied" and "Splashed White" Patterns in Horses and Ponies, V. M. Klemola, 65.
Pigs Born Without Eye Balls, F. Hale, 105.

Plant Breeding and Plant Genetics:

Broad Bean Genetics, 137.
Bud Variations in the Agen Prune, 289.
Bud Pollination in Cabbage and Radish, 359.
Chlorophyll Mutation in Wheat, 159.
Chromosomes of the Potato, 86.
Chromosomes of Triploid Tradescantia, 253.
Culture of Sweet Cherry Embryos, 7.
Cytology for the Plant Breeder, 115.
De Vries, Mendelism Rediscovered, 3.
Dwarf Character in Maize, 279.
Iarovizing Wheat, 165, 169.
Liguless-2 in Maize, 325.
Maize, Silky Ears, 41.
Marsh Seedless Grapefruit, 437.
Nut Growing, 356.
Plant Breeding up to Date, 286.
Poplar Hybrids, 217.
Pseudogamy in Blackberries, 313.
Radium-Induced Variations, 129.
"Reverse" Mutation in the Apple, 48.
Sorghum Dwarf, 337.
Spotting in Bean, 481.
Strawberry Breeding, 391.
Waxy Endosperm in Sorghum, 257.
What is a Gene?, 369.
Wheat-Couch Grass Hybrids, 329.

Plant Patents, 49, 55, 59, 163.

Plant Patent Queries, Robert Starr Allyn, 55.
Platypoecilus, 317.
Polyploids, 320.
Popenoe, Paul, Special Education, (Rev.), 46; L'Immigrazione degli Ebrei in Palestina nei Tempi Moderni, (Rev.), 138; Erbiologischer und Eugenischer Wegweiser fur Jedermann, (Rev.), 184; Eugenic Sterilization, 230; Human Sterilization, (Rev.), 244; Le Leggi di Mendel e i Cromosomi, (Rev.), 251; Grundzuge einer Konstitutions-Anatomie, (Rev.), 282; Guide to Medical Genetics, (Rev.), 112.
Poplars, Hybrid, 217.
Population Trends and Policies, 404.
Potato, Chromosomes of, 86.
Poultry: Spurlessness, 71; Fifth World Congress, 92; Inbreeding and Intercrossing, 93; Semi-Featherless, 101; Modifying Gene, 153; Genetics up to Date, 198; Linkage Tests, 293; Albinism, 379; Retarded Feathering, 427.
Present Position of Eugenics, 144.
"Principles of Genetics" Revised, 117.
Priority in Isolation of the Follicular Hormone, 434.
Promise of Youth, Lewis M. Terman, 435.
"Pseudo-fertility," 359.
Pseudogamy in Blackberry Crosses, G. M. Darrow and G. F. Waldo, 313.
Probability Tables, 78.
Prune, Bud Variation in, 289.
Psychiatry, 119.
Psychic Factors in Development, 248.
Pure-Bred Sires, 318.

Q

Quadruplets, Similarity of, 195.

R

Rabbit, Furless, 81; Rex-Lilac, 35.
Race Crossing, 239.
Radium and Organisms, 442.
Radium-Induced Variations in Tomato, 129.
Rambouillet Sheep, 19.
Ratios, Probability Tables for, 78.
Reaction of Dominant White with Yellow and Black in the Fowl, C. H. Danforth, 301.
Recessive Coloration in Dutch Belted Cattle, R. B. Becker, 283.
Recklinghausen's Disease, 309.
Redfield, Casper L., Why Social Invention Lags, 126.
Reed, C. A., Nut Growing, (Rev.), 356.
Religion and family size, 277.
The Restricted Extension Color Factor in Zebu Cattle, A. O. Rhoad, 347.
Results of a Project in Hybridizing Poplars, A. B. Stout and E. J. Schreiner, 217.
Retarded Feathering in the Fowl, D. C. Warren, 431.
"Reverse" Mutation in the Apple, C. E. Myers, 48.
Rexing the Lilac Rabbit, R. T. Parkhurst and W. K. Wilson, 35.
Rhoad, A. O., The Restricted Extension Color Factor in Zebu Cattle, 347.
Riddle, O., Endocrine Medicine (Rev.), 179.
Rife, D. Cecil, Genetic Studies of Monozygotic Twins, 339, 407, 443.
Robertson, Thomas E., The Commissioner Replies, 163.
Robinson, T. Ralph, The Origin of the Marsh Seedless Grapefruit, 437.
Rural Sociology in a Humane Civilization, 40.
Russian Methods for Accelerating Sexual Reproduction in Wheat, H. H. McKinney and W. J. Sando, 165.
Russian Methods of Artificial Insemination Multiply Sires' Value, Walter Landauer, 87.
Rumpless-Gene, 293.

S

Saller, K., Einfuehrung in die Menschliche Erblichkeitslehre und Eugenik, 112.
Sansome, F. W., and J. Philp, Recent Advances in Plant Genetics, 320.
Sanders, J., (sex determination), 265.
Sando, W. J., and H. H. McKinney, Russian Methods for Accelerating Sexual Reproduction in Wheat, 165; Earliness and Seasonal Growth Habit in Wheat, 169.
Sarton, George, Introduction to the History of Science, 383.
Scaling Instrument, 107.
Scapulae, 125.
Schreiner, E. J., and A. B. Stout, Results of a Project in Hybridizing Poplars, 217.
Science Through the Centuries, 383.
Scott, Winfield, Syndactylism with Variations, 241.
Seedless Grapefruit, 432.
Semi-Featherless Poultry, 101.
Sex Control Again, L. J. Cole and Ivar Johansson, 265.
Sex-Determination for the Layman, 194.
Sex Linkage in Ducks, 18.
Sex in Plants, 383.
Sex Prediction, A New Method of, 104.
Sex Research, 249.
Shamel, A. D., et al, Bud Variation in the Agen Prune, 289.
Shechurdine, A., and S. Verushkine, Hybrids between Wheat and Couch Grass, 329.
Sheep, Rambouillet, in America, 19.
Shoulderblades—"Stigma" or "Index"—?, 125.
Shull, George H., Hugo de Vries at Eighty-five, 3.
Siamese Coat Variation in Cat, 181.
Sickle-Celled Anemia, 106.
Sieglinger, J. B., A Dwarf Mutation in Kafir, 337.

Silky Maize, 41.
Silver Coat Variation in Cat, 181.
Sinnott, Edmund W., and L. C. Dunn, Principles of Genetics, 117.
Sirks, M. J., Beitrage zu einer Genotypischen Analyse der Ackerbohne, 137.
Size of Family, 275.
Sontag, L. W., and V. L. Nelson, A Study of Identical Triplets, 473.
Sorghum, Inheritance of Waxy Endosperm in, 257.
Sorsby, Maurice, Cancer and Race, 206.
"Spirazine," Theory of Life, 206.
Spotting-Genes in Cattle, 285.
Spurlessness of the White Leghorn, A. W. Kozelka, 71.
Statistical Contradictions, 364.
Steffensen, J. F., Some Recent Researches in the Theory of Statistics and Actuarial Sciences, 364.
Sterilization, Effects of, 142, 120; Legal Aspects of, 244; in Mexico, 230.
Stout, A. B., and E. J. Schreiner, Results of a Project in Hybridizing Poplars, 217.
A "Strangling" Eucalyptus, Mary Francis Baker, 403.
Strawberry Breeding, 391.
A Study of Identical Triplets, L. W. Sontag and V. L. Nelson, 473.
Stuttering, 387.
Superfetation in the Waltzing Mouse, 111.
Sweet Cherry Embryos, Culture of, 7.
Swine, Congenital Skin Tumors in, 361.
Swine, Inbreeding Berkshire, 199.
Swiss Body Measurements, 192.
Syndactylism with Variations, Winfield Scott, 241.

T

Taussig, Stefan, Grundlagen, Wege und Ziele der Okologischen Haustier-Geographie, 197.
Tempo-Genes, 315.
Ten Years of Sex Research, 249.
Terman, L. M., The Promise of Youth, 417.
Terrapins, Hybridizing Diamond-Back, 231.
Thomas Aquinas, on Sex in Plants, 385.
Thompson, Warren S., and P. K. Whelpton, Population Trends in the United States, 404.
Thomsen's Disease, R. C. Cook, 345.
Thurstone, L. L., Order of Birth, Parent-Age and Intelligence, 193.
Thyroid Deficiency, 319.
Thyroxin and Color in the Fowl, 305.
Tinkle, William J., Deafness as a Eugenical Problem, 13.
Tomato, 129.
Tooth Enamel, Absence of, 425.
Tradescantia, Chromosomes, 253.
Tree Breeding, 217.
Triplets, 195, 473.
Triploids, 115, 253.
Triticum, see *Wheat*.
Tukey, H. B., Artificial Culture of Sweet Sherry Embryos, 7.
Tumors, 310, 361.
Turtles, 231.
Twelve Years of Strawberry Breeding, Darrow, Waldo, and Schuster, 391.
Twinning in Seven Generations of the Bertolet Family, S. B. Detwiler, 139.
Twinning, Partial in Cat, 103.
Twins, 209, 281, 339, 407, 229.
Twins of the Father, 322.
Twins Reared Apart, 209.
A Two-Faced Kitten, T. H. Bissonnette, 103.

U

Unterberger's Sex-determination, 266.

V

Vernalization, 165, 169.
Verushkine, S., and A. Shechurdine, Hybrids between Wheat and Couch Grass, 329.
Von Recklinghausen's Disease, 309.
Vries, Hugo de, 3.

W

Waldo, George F., and G. M. Darrow, Pseudogamy in Blackberry Crosses, 313.
Walnut Hybrids, 357.
Waltzing Mouse, a Case of Superfetation in, 111.
Warren, D. C., Inheritance of Albinism in the Domestic Fowl, 379; Retarded Feathering in the Fowl, 431.
Waxy Endosperm, 257.
Weinstein, Alexander, The Promise of Youth, (Rev.), 417.
What is a Gene?, M. Demerec, 369.
Wheat, A Chlorophyll Mutation in, 159.
Wheat, Earliness and Growth Habit, 169.
Wheat, Russian Methods for Accelerating Sexual Reproduction in, 165.
Wheat-Couch Grass Hybrid, 329.
Whetten, Nathan L., Education and Size of Family, 275; Population Trends in the United States, (Rev.), 404.
White, Dominant, 301; Recessive, 431.
Whitney, Leon F., "Neither Dead nor Sleeping," 150.
Why Social Invention Lags, 126.
Wilson, W. King, and Raymond T. Parkhurst, Rexing the Lilac Rabbit, 35.
Woltereck, R., Grundzuge einer Allgemeinen Biologie, 248.
Wright, Sewall, Order of Birth, Parent-Age and Intelligence, 193.
Wright, Sewall, Some Recent Researches in the Theory of Statistics and Actuarial Science (Rev.), 364.

X

Xenia in Sorghum, 258.

Y

Yarovisation, see *Iarovisation*.
Yellow-Spot in Bean, 481.

A Glossary Of Genetic Terms

GENETICS has developed so rapidly that many terms in common use in genetic literature are not yet incorporated in the dictionaries. Many people who are interested in heredity are bothered by such words, for which no definition can conveniently be found. For this reason, it is proposed to publish occasionally a glossary of terms which would not be readily understood and which are not to be found except in new unabridged dictionaries. It is realized that these definitions will probably not meet with universal approval and comments and suggestions will be welcomed.

ALLELOMORPH—Mendelian characters are inherited in alternative pairs, or in alternative series. These alternative genes are called allelomorphs. Examples: Albinism (recessive), Normal pigmentation (dominant); Horns (recessive), Hornlessness (dominant).

AUTOSOMAL—Pertaining to any chromosome except the sex chromosomes.

BACKCROSS—Cross of a hybrid to one of the parental forms.

CHROMOSOMES—Tiny dark-staining bodies visible in the nucleus of the cell at the time of cell-division. The number of chromosomes in any species is usually constant. The chromosomes carry the genes, linearly arranged, which control the development of Mendelian characters.

DIPLOID—Having two sets of chromosomes. Body-tissues of higher plants and animals are ordinarily diploid in chromosome constitution. See *Somatic*.

DIZYGOTIC—Originating from two fertilized eggs. Dizygotic twins are genetically no more similar than ordinary brothers and sisters.

DOMINANT—A character possessed by one of the parents of a hybrid, which appears in the hybrid to the exclusion of the contrasted character from the other parent (the recessive). Thus in a cross of green- and yellow-seeded peas the first generation has yellow seeds. Yellow is dominant and green is recessive, being transmitted but not appearing in the presence of the factor for yellow.

EXTENSION FACTOR—A factor (gene) which extends the action of a primary gene. Thus, a spotting gene produces larger spots, or even an entirely pigmented coat in the presence of an extension factor.

FACTOR—Same as *Gene*.

F_1—(Pronounced eff-one). The first filial generation. The offspring of a given mating.

F_2—The second filial generation. Produced by intercrossing or self-fertilizing the F_1. The inbred grandchildren of a given mating.

GAMETE—A reproductive cell of either sex; e. g. sperm or ovum.

GENE—(1) The unit of inheritance, which is transmitted in the germ cells, and which by interaction with the genic and cytoplasmic complex controls the development of a character. The genes are arranged linearly in the chromosomes. (2) "The physical basis of heredity"—or more figuratively, the atom of the genetic molecule.

GENOTYPE—The entire genetic constitution expressed and latent, of an organism.

HETEROZYGOUS—Containing both genes of an allelomorphic pair, or two genes of an allelomorphic series. Heterozygous individuals generally resemble the individuals homozygous for the dominant character, but they transmit the recessive to half their offspring.

HOMOZYGOUS—(1) An organism formed by like germ cells; (2) An organism is said to be homozygous for a given character when all the germ cells transmit identical genes for this character. This is the most frequently used meaning of the term.

LINKAGE—Association of genes in inheritance, due to the fact that they are in the same chromosome.

MONOZYGOTIC—Originating from a single fertilized egg cell, which in the course of subsequent development has given rise (by fission) to two or more individuals. Twins (or triplets, etc.) of such origin are, barring mutations, genetically identical.

MULTIPLE FACTORS—In the expression of some characters more than two genes are necessary. Such cumulative or cooperative genes are called multiple factors.

MUTATION—A sudden variation in an inherited character.

PHENOTYPE—The organism as exemplified by its expressed characters, as contrasted with its genetic constitution (the genotype).

RECESSIVE—See *Dominant*.

SEGREGATION—Separation of allelomorphic genes at meiosis.

SELFED—Self-pollinated.

SOMATIC—Referring to body tissues; having two sets of chromosomes, one set normally coming from the female parent and one from the male; as contrasted with germ cells having a single set of chromosomes.

ZYGOTE—An organism produced by the union of two germ cells.

WHAT OF THE FUTURE?

THIS issue of the JOURNAL OF HEREDITY completes the twenty-fourth volume. The first publications of the Association appeared in 1904—only four years after the rediscovery of Mendel's work by De Vries, Correns, and Tschermack. The record is one upon which we can justly pride ourselves. What the future holds depends on the present membership of the American Genetic Association.

In May, 1933, when the financial outlook was especially dark, we outlined briefly in this same space the serious situation which then confronted us. Even with some improvement in recent weeks, that statement gives in brief form a fair résumé of the paradox of the printing press, which still is not resolved. We are therefore republishing this statement in part, as a preliminary introduction to the twenty-fifth volume of the JOURNAL.

"BUT A LITTLE TO EACH OF YOU"

Whether one copy of the JOURNAL is printed or ten thousand, many of the larger costs of preparation would be the same. The entire expense of typesetting, halftone engravings, editing, correspondence with authors regarding articles, proof, etc., must be incurred before a single copy can be mailed. On the most economical basis these preliminary expenses would amount to over $400.00. If ten thousand copies are printed instead of one, the additional cost of paper, of binding and trimming the extra copies, etc., would amount to only about $400.00. Thus, the cost of the 9,999 additional copies would be less than that *first* expensive copy. The cost of these additional 9,999 copies is about *four cents each.* If we lump our expenses for these two runs, and distribute all the costs over ten thousand copies, the production cost of each copy is eight cents, as compared with a production cost of $400.00 for publishing but one copy.

These facts have an interest to every member of the A. G. A. because they have a very important bearing on the future of the JOURNAL—economic conditions being as they are. The greater part of the income available for publishing the JOURNAL is derived from the dues paid by every member. Whenever a member withdraws for economic or other reasons, our income is reduced $3.00 *but our expenditures cannot be reduced in proportion.* It is easy to see that even a rather small percentage of withdrawals may threaten with financial disaster a publication operating near the margin between available funds and necessary costs. Thus a ten per cent reduction in membership and subscriptions (350) means about $1,100 less income, but our production costs can be reduced only about $175.00, leaving a deficit of nearly a thousand dollars to be met in other ways! * * * The publication of the JOURNAL is made possible by these individual contributions which, "though but a little to each of you, represent a goodly sum in the aggregate."